

**INTEGRATED PEST MANAGEMENT PLAN FOR ERADICATING
ELODEA FROM WATER BODIES IN INTERIOR ALASKA**

January 2017

Prepared by

Fairbanks Elodea Steering Committee

AK Department of Environmental Conservation

AK Department of Fish and Game

AK Department of Natural Resources

City of Fairbanks, Public Works Department

Fairbanks Soil and Water Conservation District

National Parks Service

US Fish and Wildlife Service

In consultation with:

Scott Schuler (SePRO Corporation, Carmel, IN)

Andrew Skibo (SePRO Corporation, Fort Collins, CO)

TABLE OF CONTENTS

- I. Abstract
- II. Background and Problem Statement
- III. Management Goals and Objectives
- IV. Status of *Elodea*
 - Taxonomy
 - Biology and invasive potential
 - Distribution
 - Ecological impacts
 - Economic impacts
- V. Site descriptions
 - Chena River
 - Chena Slough
 - Chena Lake
 - Totchaket Slough
- VI. Review of Management and Treatment Options
 - Treatment options
 - Proposed management method
 - Herbicidal eradication of *Elodea*
 - Fluridone
 - Diquat
- VII. Proposed treatments
 - Mechanical treatments
 - Chena River
 - Herbicide treatments
 - Chena Slough
 - Chena Lake
 - Totchaket Slough
 - Pesticide application procedures
- VIII. Monitoring and Assessment
- IX. Preventing spread of *Elodea*
 - Surveying
 - Outreach and education
- X. Budget
- XI. Administrative Record
- XII. Figures and Tables
- XIII. References

I. Abstract

Elodea is an aggressive invasive aquatic plant that was first detected in the Chena River system in 2009. Surveys conducted in 2011 and 2012 revealed that the lower 10 miles of Chena Slough is heavily infested with *Elodea*. In addition, Chena Lake, at Chena Lakes Recreation Area is infested with *Elodea*, and a few isolated patches were found in the Chena River. In 2015, the Totchaket Slough, a slackwater slough located about 60 miles downriver of Fairbanks, was found to be heavily infested as well. In Alaska, *Elodea* infestations in water bodies can be expected to increase sedimentation, displace native vegetation, reduce biodiversity, degrade sensitive fish habitat, and interfere with safe river travel. A quarantine established at the boundaries of Alaska by the State Department of Natural Resources in 2014 underscores the gravity of this threat. *Elodea* can be spread readily via boats and floatplanes, and because it reproduces vegetatively, a single fragment is all that is needed to start a new infestation. Here we propose an integrated pest management approach to curb the spread of, and eventually eradicate, this species in water bodies in the Fairbanks, North Pole, and Nenana areas. We propose to use suction dredging in the Chena River, and aquatic herbicide treatments in Chena Slough, Chena Lake, and Totchaket Slough.

II. Background and Problem Statement

In September 2010, floating fragments of *Elodea* were found in the Chena River. This discovery was traced upstream to a dense ten-mile long infestation of *Elodea* in Chena Slough. This discovery launched an intensive effort to document the distribution of *Elodea* in the Fairbanks North Star Borough and to control the spread of this invasive plant to other regions of the state. In 2009, the State of Alaska and United States Fish and Wildlife Service published a list of native and non-native aquatic plants in Alaska (Portland State University 2009). At that time the authors determined that *Elodea* is non-native to Alaska. This determination was based on scientific information garnered from museum specimens archived at the University of Alaska Fairbanks Museum of the North that document the aquatic plant diversity and distribution within the state. The authors also conducted vegetation surveys to validate these determinations. Following this, an intensive effort was launched to document the distribution of *Elodea* in the Fairbanks North Star Borough (Fig.1) and to control the spread of this invasive plant to other regions of the state. In 2013 and 2014, manual and mechanical treatment trials were conducted in Chena Slough. These methods were found to be labor-intensive and time consuming and resulted in large-scale fragmentation of *Elodea*, increasing the threat of downstream invasion (Lane 2014).

In 2015, *Elodea* was discovered in Totchaket Slough by foresters from Tanana Chiefs Conference. This discovery prompted a rapid and extensive survey of water bodies in interior Alaska conducted by National Parks Service (NPS), United States Fish and Wildlife Service (USFWS), and Fairbanks Soil and Water Conservation District (FSWCD). In particular, sloughs and wetlands located adjacent to the Tanana and Tolovana Rivers that seemed to present suitable habitat for *Elodea* establishment, between Fairbanks and Minto were surveyed for the presence of *Elodea* (Fig.2). In addition, selected lakes and streams in the Salcha-Delta region were surveyed. No *Elodea* was detected in the water bodies visited during these surveys.

The *Elodea* infestations in Chena and Totchaket Sloughs are a high priority management issue in the region because of the coverage and density of the infestations, and the sloughs' connectivity to downstream river systems. These river systems include critical rearing and migratory habitat for Chena, Tanana, and Yukon River Chinook salmon, Arctic grayling, and other important subsistence and sport fish species (Dion 2002, Ihlenfeldt 2006). The Chena River system and other water bodies in the Fairbanks area are used by a wide array of groups, including motorized and non-motorized boaters, fishermen, hunters, and other recreational users. Due to the wide array of users, there is a high potential for spreading this plant to non-infested water bodies. If *Elodea* becomes established in local floatponds, it could be spread by floatplane throughout the state of Alaska. Thus the Fairbanks *Elodea* Steering Committee has chosen to pursue the use of herbicides to eradicate *Elodea* while continuing public outreach and education on this invasive species and how to prevent its spread.

Elodea is Alaska's first invasive aquatic plant. Recognizing the threat it posed in 2012, the State of Alaska charged the Alaska Department of Natural Resources (ADNR) with the responsibility to manage invasive aquatic plants. In 2014, ADNR Division of Agriculture

established a quarantine of aquatic invasive weeds at the boundaries of Alaska to prohibit the entry and spread of five aquatic species, including *Elodea*. These management efforts were implemented in part to address current *Elodea* infestations in Alaska. ADNR has set a statewide management goal to eradicate *Elodea* and prevent it from spreading. This goal is being carried out in conjunction with local organizations, such as the FSWCD and the Fairbanks *Elodea* Steering Committee.

III. Management Goals and Objectives

Goal: The primary goal is to eradicate *Elodea* and to prevent its spread into uninfested waterbodies. Doing so will restore fish and aquatic habitat and recreational opportunities in the infested water bodies. An additional goal is to choose the most effective and appropriate method to eradicate *Elodea*. Eradicating *Elodea* and other aquatic invasive plants supports maintenance of intact, functioning aquatic ecosystems.

An integrated pest management (IPM) plan is a sustainable approach to managing pests that uses one or a combination of tools such as prevention, no action, biological, cultural, mechanical/physical and herbicide treatments in a way that minimizes health, environmental and economic risks. This IPM describes several different objectives, all leading to the ultimate goal of eradicating *Elodea* from interior Alaska.

The following objectives and strategies were developed to guide and implement this IPM.

Objective 1: Fulfill Regulatory and Policy Requirements

Strategies:

- Conduct outreach and education to the public, and receive public input, on the current status of the *Elodea* infestation and treatment alternatives prior to and during the environmental assessment analysis phase.
- Prepare planning, regulatory and NEPA documents. This strategy includes conducting a formal environmental assessment (EA) to solicit public and stakeholder input into the selection of treatment alternatives including the *Elodea* Steering Committee's preferred treatment to eradicate *Elodea* with herbicide, preparing this integrated pest management plan, and applying for a pesticide use permit.
- Develop viable treatment alternatives, including individualized herbicide treatment prescriptions for each affected waterbody to be used in permitting applications.
- Finalize the EA and submit to US Fish and Wildlife Service for review
- Solicit public comments during DEC pesticide use permit comment period
- Finalize draft of IPM and acquire stakeholder signatures

Objective 2: Implement treatments in *Elodea* infested waterbodies.

The waterbodies will be treated in the following order of priority: 1) Chena Slough, 2) Totchaket Slough and 3) Chena Lake.

The Action Threshold at which point an approval management strategy will be implemented to eliminate the *Elodea* population, will be considered as the presence of *Elodea*. Therefore, presence of *Elodea* in a waterbody, at any density or percent cover, is sufficient to trigger eradication efforts by approved methods.

Strategies:

- Develop herbicide treatment prescriptions for each affected waterbody in consultation with EPA-certified pesticide manufacturers, ADEC, and ADNR.
- Implement best management practices to eliminate/reduce potential impacts to non-target resources and to prevent spread of *Elodea* when treating different water bodies.
- Trained and certified pesticide applicators will comply with all Federal, State, and local pesticide use laws and regulations.
- Provide advance notification to the public and private property owners of all intended applications
- Maintain herbicide labels and MSDS as required, and maintain records of applications
- Monitor fluridone concentration in treated water bodies using the FasTest sampling protocol described in this document
- Make FasTest results of fluridone concentrations in treated waterbodies available online.

Objective 3. Survey high priority (or at-risk) waterbodies annually for invasive aquatic species infestations using a reconnaissance survey approach.

Strategies:

- Work with partners (e.g. USFWS, NPS, DNR, and floatplane pilot's associations) to identify high priority waterbodies
- Develop a sampling plan.
- Work with others to conduct surveys of new and previously surveyed waterbodies as funding permits
- Work with others to map surveyed areas as funding permits
- Formalize sampling protocol to be shared with statewide invasive plant management community
- Continue to seek and acquire funding to conduct fieldwork

IV. Status of *Elodea*

Taxonomy

Five distinct species of *Elodea* are recognized, all native to parts of North and South America (Cook and Urmi-König 1985, Bowmer et al. 1995). Plants collected in Chena Slough in 2009 were initially identified by University of Alaska Museum of the North botanists as *Elodea canadensis* based on their morphological characteristics, though not recognized as invasive at the time. In 2010, samples were sent to University of Connecticut researchers for DNA analysis. Results showed specimens to be *Elodea nuttallii*. More sampling and genetic analyses are needed to determine definitively which species of *Elodea* occur in the slough. It may be *E. nuttallii*, *E. canadensis*, or a hybrid of the two. Because of this uncertainty, throughout this document we refer to the plant found in the Fairbanks area simply as *Elodea*.

Biology and Invasive Potential

Both *E. canadensis* and *E. nuttallii* are perennial submersed aquatic plants that propagate primarily through vegetative means. Propagation occurs when stem fragments are dispersed via water current, floating debris, wave action, or through human and wildlife activity (Spicer and Catling 1988, Barrat-Segretain and Elger 2004). Both species have high regeneration (regrowth into viable plants) and colonization rates. Both species can withstand strong current and survive long distance dispersal, increasing invasion capabilities (Barrat-Segretain et al. 2002). Dispersing fragments grow roots at stem nodes where fragmentation occurred (Spicer and Catling 1988). Although very little is known about seed production and germination in Alaska, seed production in the *Elodea* genus is considered rare (Bowmer et al. 1995). The length of seed viability and life are also unknown (Spicer and Catling 1988).

Elodea species are generally tolerant of a wide variety of growing conditions; however, the plant prefers cold, clear, slow moving water for optimal growth (Cook and Urmi-König 1985). Both species grow in water temperatures of 10-25°C and prefer depths ≤ 10 ft, but will eventually spread to water depths of 15-20 ft. The growth of *Elodea* is stimulated by fertilization with nitrogen, phosphorus, and potassium (Best et al. 1996). *Elodea* can survive and grow under ice (Bowmer et al. 1995) continuing to photosynthesize in lighting conditions of 29 to 120 foot-candles (Stuckey et al. 1978). Plants overwinter in water temperatures of 1-4°C (Stuckey et al. 1978). *Elodea* develops dormant overwintering apices with densely crowded and strongly cuticularized leaves that are much hardier than the summer growth (Spicer and Catling 1988). Overwintering buds can occur at densities of up to 5000/m² (Bowmer et al. 1984). Overwintering buds are generally produced in autumn, and remain in the substrate until temperatures increase in the spring (Bowmer et al. 1984). As winter ends, growth is able to continue after only a few days of temperatures above 18°C (Sculthorpe 1967).

There are some critical differences between the two species that may affect their hybrid. *E. canadensis* prefers mesotrophic lakes (moderate nutrient levels) whereas *E. nuttallii* prefers eutrophic lakes (high nutrient levels) and can tolerate higher levels of pollution. Both species are

salt intolerant but to varying degrees: $\leq 0.25\%$ for *E. canadensis* (Sand-Jensen 2000) and $\leq 1.4\%$ for *E. nuttallii* (CAPM 2004); for comparative purposes, ocean water is typically 3.5% salt.

Elodea species are well documented as invasive aquatic plants that have successfully invaded many areas throughout Europe and Asia (Nichols and Shaw 1986), as well as New Zealand, Australia (Cook and Urmi-König 1985) and parts of Africa. In Europe, *Elodea* infestations have spread extensively across the landscape over the last 140 years, likely because of human movements inadvertently transporting plant fragments. *Elodea* has spread from Ireland to Lake Baikal, Russia—a distance of approximately 5,000 mi (8,000 km)—and crossed two continental divides. *Elodea* species are capable of causing large-scale changes to freshwater ecosystems, including changes in stream-flow dynamics, nutrient content, dissolved oxygen content, and invertebrate assemblages (Buscemi 1958, Pokorny et al. 1984). Its rapid growth often results in the displacement of native plants, which can significantly alter fish and aquatic invertebrate habitat. Dense *Elodea* growth also interferes with recreational activities, such as fishing, swimming, and boating, and can create hazardous conditions for float aircraft operations.

Distribution

North America

(The following is from Morton et al. 2014)

Elodea nuttallii (commonly known as Western Waterweed or Nuttall's Waterweed) is native throughout much of North America from the southeastern United States into southern British Columbia. *Elodea canadensis*, or Canadian waterweed, is native to temperate North America; its distribution includes northern portions of the contiguous U.S. and southern Canada, excepting southern Alberta and southwestern Saskatchewan. Distribution is highest in parts of Quebec, the St. Lawrence Valley, the Great Lakes region, southern British Columbia, and the Pacific West Coast. *E. canadensis* is infrequent north of 51°N but it does occur as far north as 59°N. *Elodea* species are absent from northern Canada including the Yukon and northern British Columbia, displaying a sizeable gap in distribution between recent discoveries of *Elodea* in Alaska and the previously known northernmost locations in North America: approximately 615 miles from Cordova, 800 miles from Kenai-Soldotna, and 725 miles from Fairbanks. Furthermore, the Canadian locations are on the opposite side of the Coastal Range; a significant geographic barrier to dispersal. The native range of *E. nuttallii* overlaps *E. canadensis*, but the former is more prevalent further south.

Alaska

To date *Elodea* has been found in 22 locations within the state of Alaska (Fig. 3) including infestations near Fairbanks, Anchorage, Cordova, and Kenai. All but one of the infestations have been identified since 2009. These searches have been conducted by land management agencies and the *Elodea* Steering Committee. Two infestations have been identified by citizens and reported to the state.

Though *Elodea* is native to much of North America, several lines of evidence show that it is not native to Alaska. *Elodea* was judged to be a “Potential Invasive” to Alaska in the book “Introduction to Common Native and Potential Invasive Freshwater Plants in Alaska.” This book

was written jointly by the Center for Lakes and Reservoirs at Portland State University, Alaska Department of Fish and Game, and the U.S. Fish and Wildlife Service, and published in 2009, prior to the discovery of the severe infestation in Chena Slough. Additional lines of evidence are detailed by Wurtz et al. (2013). The Arctos online database includes more than 1500 aquatic plant specimens widely collected across Alaska. The collection includes only one specimen of *Elodea* collected prior to 2009: the sample was from Eyak Lake. The Eyak Lake population is now believed to have begun with an aquarium dump. *Elodea* has not been found in the Yukon region. Numerous floristic surveys have been conducted in Alaskan habitats that would seem to be good *Elodea* habitat – for example, water bodies in Minto Flats and the Yukon Flats.

Fairbanks

To date, *Elodea* has been found in four waterbodies in interior Alaska: Chena Lake, Chena Slough, the Chena River, and Totchaket Slough (Fig. 2). Since 2011, a variety of different groups and government agencies have surveyed a range of different water bodies in interior Alaska. To date, all anadromous stream crossings within the Fairbanks North Star Borough have been surveyed at least once, along with known boat launches, selected float plane ponds, and many high use areas (Fig.1). Additional surveys have been conducted in gravel pits located within a half mile of Chena Slough.

A survey conducted by FSWCD in 2011 focused on the lower 10 miles of Chena Slough. Of the approximately 118 acres of slough in this 10-mile reach, *Elodea* was found to occupy 55 acres with coverage ranging from 1% to 100% (Fig. 4). Isolated patches were found downstream in the lower Chena River. The Chena Lakes population was initially detected around a boat launch in the lake, and a survey conducted in 2012 showed that *Elodea* is present throughout much of the perimeter (Fig. 5). Chena Lake's only outflow is via groundwater, so the *Elodea* in Chena Lake is confined to the lake unless moved by people or vehicles.

In August 2015, foresters working for the Tanana Chiefs Conference reported an infestation of *Elodea* in Totchaket Slough, a slough of the Tanana River 12 miles downstream of the village of Nenana. This infestation was found to cover a 5.5-mile stretch of the slough that begins just upstream of the mouth and extends the entire length of the slough (Fig.6).

Ecological Impacts

Elodea can form dense mats, reducing the amount of light available to surrounding native aquatic plant species (Rorslett et al. 1986, Spicer and Catling 1988) resulting in displacement of native flora and a loss in plant species diversity when it becomes the dominant cover type. These dense *Elodea* populations can restrict water flow (Spicer and Catling 1988, Gollasch 2006) and impede navigation. *Elodea* accumulates nutrients while reducing nutrient availability to the substrate with unknown effects on stream productivity. *Elodea* infestations degrade water quality and thus aquatic fish habitat by increasing water turbidity and pH, causing changes in nutrient concentrations, and reducing oxygen concentrations near the substrate, but may increase oxygen concentrations 5 cm

above the substrate, thus its use in fish aquariums. *Elodea* can also withstand desiccation and low water temperatures and can survive in nutrient poor environments.

Outside of its native range, new infestations of *Elodea* establish with a relatively explosive growth period that lasts 5 – 6 years (Sand-Jensen 2000, Mjelde et al. 2012). Predictive bioclimatic models that include climate warming, suggest that *Elodea* will continue to aggressively colonize even further north in Europe (Heikkinen et al. 2009). Similar studies have not been conducted in Alaska; however, given climate warming predictions for the state of Alaska (ACIA 2005) northward migration of *Elodea* within the state is highly likely.

Until the ADNR Division of Agriculture established a quarantine in 2014 at the boundaries of Alaska to prevent the entry and spread of *Elodea* species, *Elodea* was commonly used as an aquarium plant in Alaska and had been readily available in pet stores. It was frequently used in college and high school biology labs for experiments in plant cellular structure, living protoplasm, respiration, photosynthesis and other physiological processes (Catlin and Wojtas 1985). The *Elodea* infestation in Chena Slough is likely to have originated from dumped aquarium material.

In Alaska, *Elodea* appears to be isolated to aquatic habitats near urban centers with a few exceptions (Fig. 3). In these locations it is an aggressive invader that is expected to have severe impacts on aquatic ecosystems including: loss of habitat for wetland obligate species such as moose, waterfowl, and furbearers as well as salmon and other resident fish, reduced biodiversity, increased sedimentation, degradation of water quality, and displacement of native vegetation. Dense surfacing plants also impede water craft navigability and create hazardous conditions for float plane operations. This infestation is likely to result in significant economic impacts to tourism, sport & commercial fishing, and other stakeholders.

Given the plants tolerance to clear, slow flowing waters, its complex life history and its ability to easily colonize aquatic environments *Elodea* poses a significant threat to the state's vast aquatic resources.

Economic Impacts

Because the invasion of Alaskan water bodies by *Elodea* is relatively recent, it is difficult to assess the economic impacts of the invasion on the state and its people. Outside Alaska however, millions of dollars have been spent attempting to stop the spread of *Elodea* or control its explosive growth. For example, in Great Britain, the management of invasive aquatic plants costs between \$44 and \$60 million annually with *Elodea* management being the single largest expense, comprising more than a quarter of total cost (Oreska and Aldridge 2011). In 2005, the State of Florida spent 22.5 million dollars for aquatic plant control in public waters alone. In Orange Lake, Florida the sport fishery is thought to have suffered a 90% loss in revenue due to *Hydrilla* infestation (Colle et al. 1987). Cases outside Alaska suggest that once *Elodea* is established it can significantly increase management costs and lead to deterioration of recreational boating opportunities, fouling of boat propellers and floatplane rudders, impediment to fishing, and a reduction in property values (Zhang and Boyle 2010). In Wisconsin, property values dropped by approximately 13% following an infestation of Eurasian milfoil (Horsch and

Lewis 2008). Infestations of *Elodea* have been shown to damage the aesthetic values of waterways and reduce recreational opportunities as well (Catlin and Wojtas 1985, Josefsson and Andersson 2001).

In Alaska, *Elodea* could significantly impact the subsistence community and thousands of peoples' ability to survive by impairing their ability to hunt, fish, and trap. Many Alaskans rely on subsistence resources such as salmon, whitefish, waterfowl and moose, that are dependent on healthy aquatic ecosystems. Not only do Alaska subsistence users harvest fish and game that depend on these waters but waterways are also significant means by which Alaskans traverse the state in pursuit of fish and game. The presence of *Elodea* in our waters could curtail these cultural activities.

V. Site Descriptions

All four known *Elodea* infestations in interior Alaska are part of the Tanana River watershed. The Tanana River bisects the state of Alaska traversing 568 miles from the headwaters in Wrangell-St. Elias National Park to the mouth of the Yukon River.

Chena River

The Chena River is a non-glaciated tributary of the Tanana River. The Chena River originates in the Yukon-Tanana Uplands approximately 90 mi east of the city of Fairbanks, AK and flows 155 mi to its confluence with the Tanana River southwest of the city of Fairbanks draining an area of approximately 2,115 mi², with an elevation change from 3,675 ft at its origin to 430 ft at the confluence with the Tanana River (Tetra Tech 2011). High flows generally occur in the Chena River from May to September. During winter months (November to April) the principal source of flow for the Chena River and related tributaries is groundwater. The mean annual flow rate in the upper Chena River (USGS gauge at Milepost 40 of Chena Hot Springs Rd) is 689 cfs. In downtown Fairbanks (USGS gauge at Wendell Street Bridge) the mean annual flow rate is 1,344 cfs (USACE 1997).

The lower portion of the Chena River is heavily urbanized. The Chena River flows through Fort Wainwright Army Base, an area that is on the National Priorities List because of known or threatened releases of hazardous substances, pollutants or contaminants (Gilder 2011). Some contaminated sites are directly adjacent to the Chena River and include soils around landfills, drum storage and disposal, areas around pipelines and fuel-loading facilities. The segment of the Chena River from the mouth to Fort Wainwright was added to the Alaska 1994 Clean Water Act (CWA) section 303(d) list of petroleum hydrocarbons/oil and grease and sediment by the ADEC (Gilder 2011). Clean up in the mid-1990s by the US Army led to the Chena River meeting water quality standards, resulting in removal from the list for hydrocarbons/oil and grease in 2010; however as of 2011 it remained on the list for sediment (Gilder 2011).

As much as 50% of the Chena River Basin is underlain by permafrost (USACE 1993 as cited in Talbot et al. 2006) and bogs and sloughs are common throughout the watershed. Many vegetative communities are represented throughout the watershed including: willow, herbs, white and black spruce, balsam poplar, aspen, tamarack, dwarf birch, feather moss, prickly rose,

mosses lichens, Labrador tea, wildflowers, high and low bush cranberries, blueberries, cloud berries, raspberries, and currants (Talbot et al. 2006).

The Chena River supports one of the largest Chinook salmon populations in the Alaska portion of the Yukon River drainage, with an average return of over 4,800 fish from 2004-08 (Brase 2009). All Chinook salmon spawning is thought to occur above the Moose Creek dam (Brase 2009). Other fish species present in the Chena River are chum salmon, Arctic grayling, burbot, round whitefish, humpback whitefish, longnose sucker, slimy sculpin, lake chub, Arctic lamprey, Alaska blackfish, sheefish, least cisco, and northern pike.

The watershed has important breeding habitat for 93 species of birds and 35 other species are found during spring and fall migrations (Talbot et al. 2006). Waterfowl, shorebirds, raptors, and songbirds are represented (Talbot et al. 2006). Mammals present in the watershed include moose, wolf, coyote, Northern flying squirrel, red squirrel, snowshoe hare, beaver, mink, red fox, and lynx (Talbot et al. 2006).

Chena Slough

The Chena Slough is located in T1S, R1E, sections 11-14, and R2E, sections 18-20, 29, 32 and 33. Chena Slough itself is a small tributary of the Chena River, which is a major tributary of the Tanana River which flows into the Yukon River. The slough is fed by groundwater and runoff, originating south of North Pole, and drains into the Chena River. Chena Slough has been heavily modified over the years to prevent flooding in Fairbanks and to ensure safe fish passage (Williams 1950, Neill et al. 1984, Ihlenfeldt 2006). Originally a swift-flowing channel connecting the Tanana to the Chena River, the Chena Slough was dammed by the Moose Creek Dike in 1945 to prevent flooding in downtown Fairbanks. After the catastrophic flood of 1967, many bridges and fish passage culverts on the Slough were hastily replaced. Construction of the Chena Lakes Flood Control project in the 1970s further reduced flow into the Slough. Restoration of fish passage in Chena Slough is ongoing, with 7 culverts replaced since 2000 (Ihlenfeldt 2006).

Chena Slough is heavily urbanized and flow has been minimized to reduce downstream flooding in Fairbanks. Houses abut virtually the entire length of the slough. This has led to a suite of problems including urban runoff and septic leakage. These in turn have led to increased growth of aquatic vegetation and eutrophication, leading to thick deposits of organic mud and increased suspended debris (Dion 2002). Increased emergent and terrestrial vegetation has also encroached on Chena Slough (Dion 2002). In addition, sediment and water have become impounded upstream of many road crossings (Chena Slough Technical Committee 2005). The actual ownership boundaries of the Chena Slough basin are under some dispute. Because the water course has narrowed so much in the last 50 years, there is disagreement between private property owners along the slough banks and the State of Alaska on where the property boundaries are. The Fairbanks North Star Borough plat maps treat this issue inconsistently (C. Everett, personal communication, March 14, 2011).

Today Chena Slough is approximately 17 mi in length and runs from the city of North Pole to the Chena River, 5 mi east of Fairbanks, with the watershed encompassing approximately 26 mi². The land is relatively flat with a 16 ft elevation difference between the headwaters and the confluence with the Chena River. Most of the channel is 65-99 ft wide and 3 ft deep, and the gravel streambed is overlain with a thick layer of organic mud (Dion 2002). Current stream flow is mainly from ground water upwelling from the Tanana Aquifer (Dion 2002) supplemented by runoff from roads and drainage ditches (Tetra Tech 2011, Hydraulic Mapping & Monitoring 2013). Some portions of Chena Slough remain open during the winter due to groundwater, making breakup on the river occur earlier and often well before the Chena River.

Much of the area between Chena Slough and the Richardson Highway is periodically flooded. In 2002, aquatic vegetation in the slough consisted of *Hipparus vulgaris*, *Potamogeton alpinus*, *Sparganium* sp., and *Ranunculus aquatilis* (Dion 2002). (No *Elodea* was found when Dion did her 2002 survey, but she did not sample the entire slough systematically.) Diatoms, *Nostoc* sp., and filamentous algae are also present (Dion 2002).

Chena Slough was recognized in the 1990s as a world-class catch-and-release sport fishery for Arctic grayling that provided important spawning and rearing habitat for Arctic grayling (Dion 2002). Other fish species documented in the slough include Chinook salmon, chum salmon, northern pike, round whitefish, Arctic lamprey, Alaska blackfish, long-nose sucker and slimy sculpin (Ihlenfeldt 2006). Beavers, muskrat, and waterfowl also use the Slough (Kennedy and Hall 2009). Planktonic organisms include copepods, daphnids, ostracods, Ephemeroptera, Plecoptera, and Tricoptera (USACE 1997). In 1997 it was estimated that 30 to 50% of the arctic grayling in the entire Chena River system were spawned in Chena Slough (USACE 1997). Though the Alaska Department of Fish and Game has not released data on Chena Slough alone, mean annual grayling catch in the Chena River below Moose Creek Dam (combined with Chena Slough and Noyes Slough) declined between 2000 and 2010 (ADFG 2016).

Chena Lake

Chena Lake has a surface area of 234 acres and a maximum depth of 38 ft. Chena Lake is located in T1S, R3E, section 31 and T2S, R3E, section 6. The lake is fed by groundwater and has no above-ground outflow. Chena Lake is located 17 mi east of Fairbanks on the Richardson Highway, 3 mi from North Pole, on the Tanana Lowland which is a wide floodplain underlain by thick beds of stratified gravels. The lake is a borrow pit that was rehabilitated in 1984 and has been designated as a Fairbanks North Star Borough Recreation Area. Local residents and visitors commonly use this area for non-motorized boating and fishing.

Spruce, tamarack, and birch forest surrounds the lake (ADFG 2011). Open land, marshes and sloughs also provide habitat (ADFG 2011). Several native and non-native terrestrial plants were introduced for re-vegetation and to control erosion from 1977-79 (Johnson et al. 1981).

Chena Lake has been stocked by Alaska Department of Fish and Game with Rainbow trout, Silver salmon, and Arctic char since 1982 (FNSB 2011). Goldeneye ducks, grouse, moose,

beaver, red fox, brown bear, kestrels, kingfishers, ospreys, shorebirds, swallows, muskrat, otter, mink, woodpeckers, rough-legged and sharp-shinned hawks, northern harriers, songbirds, mice, voles, hares, squirrels, lynx, wolves and black bears are all found in the surrounding area (ADFG 2011).

Totchaket Slough

Totchaket Slough is a 7-mile long clear water stream that enters the Tanana River 12 river miles downstream of the city of Nenana. The slough is located in T1S, R8W, section 32 and T2S, R8W, sections 5, 8, 17, 20, 29. The catchment area of the slough is approximately 5265 acres. It is a slow flowing stream that supports a dense population of submersed plants. The slough has a narrow riparian corridor composed largely of alder and willow. The upland habitat consists of mixed deciduous trees and large white spruce. A narrow wetland dominated by *Equisetum fluviatile* exists on the lower 0.5-mile stretch of the river.

The slough supports pike and a wide array of waterfowl species. It is an important slough for subsistence users in Nenana, who frequent the slough to harvest pike, moose and waterfowl. The surrounding land is primarily owned by the state, with a large portion held by Toghothle, the Nenana Native Corporation, and Minto Native Corporation. The slough can be accessed via boat from the Tanana River.

VI. Review of Management and Treatment Options

In 2010, shortly after the discovery of *Elodea* in Chena Slough, the Fairbanks Elodea Steering Committee (FESC) was formed to address the threat. The FESC evaluated the relative merits, drawbacks, feasibility, and costs of a wide range of options to manage and eventually eradicate *Elodea* in Chena Slough (Beattie et al. 2011). Engineering options such as drawing down the water level in the slough, mechanical options such as hand pulling, installation of benthic barriers, mechanical harvesting, and chemical methods using aquatic herbicides were considered.

Treatment Options

Option A - Take No Action

The no action alternative would maintain the status quo and *Elodea* populations would remain in all four interior Alaska waterbodies. All monitoring and education efforts would be halted. No methods of containing the spread of *Elodea* would be attempted, and the existing infestations would be left uncontrolled.

The infestation in Chena Slough has a high risk of spreading to other locations because of its connectivity to downstream river systems and the wide array of users who could potentially transport *Elodea* fragments to other waters. Similarly, the Totchaket Slough infestation is upstream of many potentially susceptible waters. Spread of *Elodea* could be very detrimental to the ecological and recreational values of water bodies throughout the region due to the prevalence of vectors of transport, thus, the no action alternative is not a viable alternative.

Option B - Mechanical/Physical methods

In 2013 and 2014, the FESC investigated the efficacy of mechanical and manual control methods for *Elodea* in Chena Slough.

Suction dredging and manual raking

Mechanical control trials on a portion of the *Elodea* infestation in Chena Slough were conducted by Fairbanks Soil and Water Conservation District (FSWCD) in conjunction with partners from Test the Waters Dive Shop. The suction dredging system consisted of a sluiceway box with an attached intake hose and dredge motor mounted on top of a pontoon boat. In shallow areas teams of volunteers used spaded pitchforks to remove *Elodea* in 65.6 ft X 65.6 ft quadrats. After two seasons of suction dredging and raking trials, it was determined that the system could be improved by increasing dredge flow rate, and increasing motor horse power. However, the main bottleneck in the process was the capacity to remove bagged *Elodea* and transport it off the work site. Suction dredging and raking were found to be extremely labor-intensive, taking approximately 400 hours of labor for 1 acre of removal (Lane 2014). In addition, these methods inevitably result in large scale fragmentation of *Elodea*, making downstream collection of fragments a major challenge. While suction dredging may be a good tool for removing small patches of *Elodea*, it is unlikely to be an effective means of complete eradication in large infestations such as the ones in Chena Slough, Totchaket Slough and Chena Lake.

Other mechanical methods

Several other mechanical methods were discussed, but had the major disadvantages of prohibitive costs of machinery (harvesting, rotoovation/cultivation), excessive fragmentation (rotoovation/cultivation, harvesting, hydraulic jets) or excessive sediment disturbance (rotoovation/cultivation, hydraulic jets). See Beattie et al. (2011) for further discussion.

Drawdown

A drawdown of waterbodies can be an effective way to kill aquatic plants. However, water bodies need an existing drain for this to be possible. Chena Slough is fed by a highly transmissive aquifer, as is Totchaket Slough. Any water drained out would be swiftly replenished, making a drawdown infeasible. Similarly, Chena Lake lacks a drain, and moreover, engineering the Lake system to be drained would be prohibitively expensive.

Benthic barriers

The installation of bottom barriers - material blocking light from reaching the plants, while still allowing decomposing gases to surface - is typically used in shallow areas near docks and shores, and is effective at reducing plant biomass without creating fragments. For the size of the infestations in all three waterbodies, the cost of using benthic barriers would be prohibitive, and the infestations are too dense to be effectively treated by this method. Additionally, benthic barriers have the disadvantage of creating an anoxic environment beneath the barrier, impacting native benthic organisms. Complete eradication of *Elodea* is impossible with this method.

Option C – Treatment with aquatic herbicides

Elodea has been found to respond to a limited number of herbicides including fluridone, diquat, terbutryne, copper sulphates or chelates of copper, and paraquat (Bowmer et al. 1995; Table 1).

Fluridone and diquat dibromide have been found to be effective herbicides for treating *Elodea* (DiTomaso et al. 2013). Fluridone is a selective systemic herbicide that ultimately kills the entire plant and can result in eventual eradication, whereas diquat is a non-selective, fast-acting contact herbicide that kills only aboveground biomass and does not result in eradication.

As a systemic herbicide, fluridone would travel through the vascular tissue of the affected vegetation and kill the root system as well as any above sediment biomass. Fragmentation would not occur, and complete eradication is possible. Fluridone is not highly toxic to fish or aquatic invertebrates. There are no water use restrictions for drinking, fishing, or swimming following an application of fluridone (USEPA 2004). Fluridone is strongly adsorbed to organic matter in soil, meaning that it does not easily move with water through a soil column (Muir et al. 1980).

Diquat is a contact herbicide, and its use would serve to reduce biomass of *Elodea*. The main advantage of this product is that it requires a relatively short contact time (around 4 hours) to be effective (Emmett 2002; Skogerboe et al. 2006). Diquat is slightly toxic to fish, but is rapidly removed from the water column. The strong chemical bonds formed by diquat adsorption to soil particles make the herbicide biologically and chemically inactive within 10 to 14 hours. Diquat alone would not eradicate *Elodea*, but its use in conjunction with fluridone could be more effective than fluridone alone in certain situations.

Proposed management method

Due to the density and distribution of the infestations near Fairbanks, as well as the threat that is posed to downstream aquatic ecosystems, the FESC has chosen to pursue the use of herbicides to eradicate *Elodea*. Several aquatic herbicides that are used for aquatic plant management were considered as a means of treating the *Elodea* infestations in interior Alaska (Table 1). Fluridone (Sonar™) was selected based on: 1) USEPA approval for its use in aquatic ecosystems, 2) the low risk posed to the environment, wildlife, and human health and safety, 3) its efficacy in treating aquatic plants at extremely low dosage, including long-term residue monitoring studies by USEPA, SePRO Corporation, as well as non-governmental, and non-industry entities, 4) DEC approval of several different formulations including liquid and time-released pellets, and 5) its demonstrated effectiveness in selectively eliminating *Elodea* from water bodies in other areas of the state (Anchorage and Kenai Peninsula). For these reasons, and due to the unfeasibility of mechanical and manual methods in treating large infestations, the FESC intends to pursue the use of aquatic herbicides to treat the Chena Slough, Chena Lake, and Totchaket Slough infestations. The Chena River infestation, on account of its isolated nature and small size will be treated using mechanical and manual methods.

The FESC proposes to use fluridone (three formulations: Sonar Genesis™, Sonar One™, and SonarH4C™) to manage the Chena Slough, Chena Lake, and Totchaket Slough infestations.

Information on diquat is included in this document for reference purposes only, so it can be considered for future use if needed.

Herbicidal treatment of *Elodea*:

Fluridone

(The following is from Morton et al. 2014)

Fluridone has been used successfully to manage *Elodea* in the Lower 48 (Dr. Lars Anderson, UC-Davis, pers. comm.). Fluridone is a selective systemic aquatic herbicide which inhibits the formation of carotene, a plant pigment, causing the rapid degradation of chlorophyll by sunlight, which then prevents the formation of carbohydrates necessary to sustain the plant. Adequate concentrations must be maintained (albeit at very low concentrations) in the treated area for 45-90 days after the initial application, which is determined through periodic water monitoring.

Fluridone is a tan to off-white odorless crystalline solid, chemically formulated as 1-methyl-3-phenyl-5-[3-(trifluoromethyl)phenyl]-4(1*H*)-pyridinone, and is applied as either a pellet or liquid (Bartels and Watson 1978, McCowen et al. 1979). Sonar™ by SePRO Corporation is a commercially available herbicide (formulations with fluridone as the active ingredient) used to selectively manage undesirable aquatic vegetation in freshwater ponds, lakes, reservoirs, rivers, and canals. Sonar is currently approved for use by the Alaska Department of Environmental Conservation in five different formulations: two aqueous suspensions known as Sonar AS (USEPA Registration Number 67690-4) and Sonar Genesis (USEPA Registration Number 67690-54), and three time-released pellet forms known as Sonar Q (USEPA Registration Number 67690-3), Sonar PR Precision Release (USEPA Registration Number 67690-12), and SonarONE (USEPA Registration Number 67690-45).

Fluridone may be applied to an entire water body (whole-lake) or on smaller infestations within a water body (partial-lake). In the former case, fluridone is generally applied as a liquid by boat through surface or underwater drip equipment depending on the size and distribution of necessary treatment areas. In the latter case, fluridone is typically applied as time-release pellets. A targeted, partial-lake treatment will result in less herbicide to the lake, reduced treatment costs, and fewer non-target impacts. In both cases, application will take place under appropriate conditions for boating, avoiding conditions of high wind, water flow, or wave action. The herbicide will be applied following all directions on the EPA approved label and will not exceed the maximum cumulative concentration (150 ppb).

Complete eradication with fluridone products generally require treatment of 45-90 days per growing season for two or more growing seasons. The ideal time for treatment is shortly after ice out (late May, early June) when plant biomass is low, turbidity is low, water volume is low, and the plant is actively growing.

Effect of fluridone on Elodea

Fluridone is a slow-acting systemic herbicide used to control *Elodea*, hydrilla, Eurasian watermilfoil and other underwater plants. Like other systemic herbicides, fluridone is absorbed from water by plant shoots and from the hydrosol by the roots of aquatic vascular plants (Marquis et al. 1981, Westerdahl and Getsinger 1988). The susceptibility of a plant to fluridone is associated with its uptake rate and rate of translocation. Fluridone interferes with the synthesis of RNA, proteins, and carotenoid pigments in plants, and disrupts photosynthesis of targeted plants. Production of carotene is inhibited, preventing carbohydrate formation that is necessary to sustain the plant. Fluridone symptoms on submersed aquatic plants appear as progressive albescence of young leaves followed by leaf necrosis, initially appearing 3—6 days after application (McCowen et al. 1979), but requiring 45-90 days for optimal lethality. Eventually, aquatic plants gradually sink to the bottom and the amount of open water increases (McCowen et al. 1979). Fluridone does not affect water quality parameters such as pH, dissolved oxygen, color, dissolved solids, hardness, nitrate nitrogen, total phosphates, and turbidity (McCowen et al. 1979).

Although fluridone is considered to be a broad-spectrum herbicide, when used at very low concentrations, it can be used to selectively remove *Elodea*, which is considered highly susceptible to the effects of fluridone (McCorkelle et al. 1992). Some native aquatic plants, especially emergent plants, are minimally affected by low concentrations of fluridone (NYSFOLA 2009). At higher concentrations, fluridone controls a broad spectrum of annual grass and broadleaf weeds, but not algae (Bartels & Watson 1978, McCowen et al. 1979, Marquis et al. 1981). Fluridone has been field tested on a variety of invasive or non-native aquatic plants including salvinia, bladderwort, Eurasian watermilfoil, coontail, pondweeds, cattail, horsetail, duckweed, fanwort, vallisneria, water hyacinth, hydrilla and *Elodea* (McCowen et al. 1979). Because fluridone does not work on algae, ponds or waterbodies with high algal concentrations should not be treated with this herbicide as the algal coating on *Elodea* can prevent herbicide absorption. Field tests in mixed invasive and native submersed aquatic vegetation showed reduction in invasive populations with native plant cover retention of approximately 70% (Madsen et al. 2002). Treatments of Michigan lakes resulted in drastic reductions in invasive Eurasian watermilfoil, increases in native submersed aquatic vegetation, and increases in size and abundance of native fish populations (Schneider 2000).

Fluridone degrades on exposure to sunlight (photolysis), adsorption to sediments, and absorption by plants. In partially-treated water bodies, dilution reduces the level of the herbicide more rapidly following application. In field studies, the concentration of fluridone (in various formulations) decreased logarithmically with time after treatment and approached zero detectable presence 64-69 days after treatment (Langeland and Warner 1986). In other studies, fluridone levels decreased rapidly to a value below detection limits after 60 days in various parts of the water column, with a half-life ≤ 7 —21 days (Kamarianos et al. 1989, Osborne et al. 1989, Muir et al. 1980, McCowen et al. 1979). Fluridone can persist in hydrosols (sediments) with a half-life exceeding one year (Muir et al. 1980).

Fluridone effects on non-target animals (including humans)

Any pesticide approved by the U.S. Environmental Protection Agency (USEPA) has undergone extensive testing to determine toxicity level through acute (high doses for short periods of time) and chronic (long term exposure) studies on animals (USEPA 1986). Fluridone has been tested in both acute and chronic studies, as well as studies to examine genetic, cancer, and reproductive effects. Fluridone was not shown to result in the development of tumors, adverse reproductive effects or offspring development, or genetic damage. Fluridone has been tested extensively on target aquatic invasive plants, as well as in long-term residue monitoring studies in treated waters.

The USEPA has approved the application of fluridone (Sonar™) in water used for drinking as long as residue levels do not exceed 0.15 parts per million (ppm) or 150 parts per billion (ppb) (USEPA 1986). For comparative purposes, 150 ppb is well below the 560 ppb set by USEPA as the maximum contaminant level (MCL). Sonar applications are allowed within one-fourth mile (1,320 feet) of a potable water intake at concentration equal to or less than 20 ppb, according to the label information. The target concentration for Chena Slough is 4-8 ppb. However, fluridone binds tightly to organic material; once applied, it is detectable only in the top 2-3 inches of sediments (Muir et al. 1980, Muir and Grift 1982), and does not reach groundwater. Label restrictions on application near drinking water are precautionary. Human contact to fluridone may be through swimming in treated waters, drinking water from treated waters, by consuming fish from treated waters, or by consuming meat, poultry, eggs, or milk from livestock that were provided water from treated waters. There are no USEPA restrictions on the use of fluridone-treated water for swimming or fishing when used according to label directions (USEPA 1986).

The maximum non-toxic dose is characterized by the “no-observed-effect-level” or NOEL for pesticides. The dietary NOEL for fluridone (the highest dose at which no adverse effects were observed in laboratory test animals fed Sonar) is approximately 8 milligrams of fluridone per kilogram of body weight per day (8mg/kg/day). A 70-kg (150 lb.) adult would have to drink over 1,000 gallons of water containing the maximum legal allowable concentration of fluridone in potable water (150 ppb) every day for a significant portion of their lifetime to receive an equivalent dose. A 20-kg (40 lb.) child would have to drink approximately 285 gallons of fluridone treated water every day to receive a NOEL- equivalent dose. The risk therefore is negligible even if a human were to accidentally ingest water directly after fluridone treatment. As fluridone is only applied intermittently and in limited areas, and because it swiftly degrades from the environment, continuous exposure over a lifetime for humans, mammals, and other animals is improbable.

Fluridone has been tested for acute and chronic toxicity, as well as reproductive effects, on mammals (rats, mice, guinea pigs, rabbits, dogs), birds (bobwhite quail, mallard duck), insects (honey bee, amphipods, daphnids, midge, chironomids), earthworms, fish (fathead minnows,

catfish, mosquitofish, rainbow trout), and other aquatic animals (Hamelink et al. 1986, Kamarianos et al. 1989, Muir et al. 1982, McCowen et al. 1979).

Exposure of test animals dermally (skin contact) has shown minimal toxicity to mammals by acute, concentrated contact. Chronic dermal exposure in mammals showed no signs of toxicity and slight skin irritation. Mammals were shown to excrete fluridone metabolites within 72 hours of varying doses of up to 1400 ppm/day (McCowen et al. 1979). A dietary NOEL was established for birds that may feed on aquatic plants or insects in treated waters. The risk to birds via diet was considered negligible. The acute median lethal concentrations of fluridone were 4.3 +/- 3.7 mg/L for invertebrates and 10.4 +/- 3.9 mg/L for fish. Fish in treated ponds have shown no fluridone metabolites after treatment (Kamarianos et al. 1989). Chronic studies showed no effects on daphnids, midge larvae, fathead minnows, or channel catfish and rapid rates of metabolic excretion (Hamelink et al. 1986, Muir et al. 1982). Insects that fed on bottom sediment had higher rates of fluridone intake and persistence than others (Muir et al. 1982). Honeybees and earthworms were not considered particularly sensitive to fluridone, even when directly dusted or placed in treated soil.

Fluridone has low bioaccumulation potential in fish, bird, and mammal tissues. Irrigation of crops using water treated with fluridone lead to only trace amounts detected in forage crops. Livestock consumption of fluridone-treated water resulted in negligible levels of fluridone in lean meat and milk. Sonar manufacturer recommendations indicate the livestock can be watered immediately from Sonar-treated water. The tolerance for milk is the same as for water (0.15 ppm).

Fluridone effects on non-target vegetation

The desired outcome of fluridone treatment is the eradication of *Elodea*, but native submersed aquatic plants may be impacted as well. Madsen et al. (2002) evaluated non-target plant effects in three lakes in southern Michigan that were treated with low-dosages of fluridone (Sonar AS®) to control Eurasian watermilfoil). Despite achieving >93% reduction in the frequency of watermilfoil, native plant cover (composed mostly of *Ceratophyllum demersum*, *Chara* spp., *Heteranthera dubi*, *Potamogeton* spp., and *Vallisneria americana*) was maintained at >70% in the year of treatment and 1-year post treatment. Floating leaf plants (such as yellow pond lily) exhibiting chlorosis (due to lack of chlorophyll) usually recover within the year of treatment or become re-established within the following year (Kenaga 1992).

Fluridone can persist for months (over the winter) in the water column when applied in autumn due to lower water temperatures and low light levels. This attribute has led managers in places where lakes freeze over to apply fluridone in the fall (WADOE 2002), allowing for longer exposure periods.

In Chena Slough and Chena Lake, *Elodea* grows both alone in monotypic stands and in mixed assemblages with other native aquatic plants as the dominant species. At the proposed low rates of application (leading to total concentrations of ≤ 150 ppb) fluridone is expected to be lethal only to *Elodea*. The aquatic plant community is expected to shift back to one comprised

entirely of native species. There may be a time period during which *Elodea* is decaying that light and dissolved oxygen may be temporarily reduced. As the plant material continues to decay, water clarity and dissolved oxygen as well as nutrient levels are expected to return to normal water quality levels.

Diquat

The current treatment prescriptions for Chena Slough, Totchaket Slough, and Chena Lake include the use of fluridone only. As this treatment program unfolds, the FESC may consider the use of diquat in targeted locations where aquatic vegetation biomass is very high. Diquat can be used in such circumstances to reduce plant biomass, and thereby increase the efficacy of the subsequent fluridone application. The requisite permitting and NEPA process will be carried out for diquat, and detailed prescriptions will be added to update the current plan at such time that a decision to use diquat is made.

Diquat is considered a moderately toxic material, labeled with the USEPA signal word “warning” (USEPA 2002). Diquat exhibits low acute toxicity via oral and inhalation exposure, but has moderate to severe acute toxicity by dermal exposure. Humans drinking water containing diquat in excess of the maximum contaminant level (MCL) over many years could get cataracts. Diquat can cause eye irritation, and can cause serious burns and scarring of the cornea (Sax 1984). Diquat may be harmful to the gastrointestinal tract, kidneys, and liver of mammals, causing severe congestion and ulceration of stomach and gastrointestinal tract (Gosselin et al. 1984).

Diquat is not known to cause genetic changes and is therefore not considered a mutagen in acute tests with mice. Diquat does not cause tumors in rat studies both acute and chronic. Tests have been conducted on mice, rats, guinea pigs, rabbits, dogs, and cows (Cochran et al. 1994, Hayes and Laws 1990). Diquat causes cataracts in dogs and rats, and developmental effects in rats and rabbits (Cochran et al. 1994). Oral diquat doses are metabolized mainly in the intestines with excretion in feces, in tests with rats, hens, and cattle. Minute traces (0.004-0.015% of oral doses) of diquat were found in cow milk, and cows are considered sensitive to diquat exposure. Diquat is considered moderately-toxic to practically-nontoxic to birds, depending on the species. In mallards, acute toxicity (LD50 or lethal dose fifty in which half of the subjects are killed with that dose) was 564 mg/kg. For domestic hens, oral LD50 was 200-400 mg/kg, for rats 120/mg/L, for mice 233 mg/kg, and 188 mg/L in rabbits. Chronic exposure at the 4-week no-observed-effect-level (NOEL) for increased relative liver weight in rats from dietary exposure to diquat was 7.2 mg/kg-day (Cochran et al. 1994).

Diquat is slightly toxic to fish. The lethal concentration fifty (LC50, in which half of the experimental subjects are killed when exposed to that concentration) was 12.3 ppm for rainbow trout and 28.5 in Chinook (king) salmon at eight hours, and 16 ppm at 96 hours for northern pike and 20.4 ppm for fingerling trout. Some species of fish may be harmed but not killed by sublethal levels of diquat, including suffering respiratory stress (yellow perch) (Bimber et al. 1976). There is no bioconcentration of diquat in fish. Diquat is toxic to aquatic invertebrates,

which display varying levels of sensitivity. Diquat has shown to be 300 more times toxic to amphipods than mayfly, with caddisfly, damselfly, and dragonfly less sensitive in that order (Nicholson and Clerman 1974, Wilson and Bond 1969).

The MCL is 0.02 milligrams per liter (mg/L) or 20 ppb for diquat (USEPA 2002). Diquat residue studies suggest that diquat is not persistent in water, as it binds to suspended particles in the water, which are then taken up by plants. The half-life is less than 48 hours in water. Affected plants decompose and release diquat, which is then degraded by microbes, photodegraded by sunlight (within 1 to 3 weeks), or adsorbed to sediment particles. Adsorbed sediment diquat is also degraded by microbial activity, although diquat has been found in the bottom soil of pools and ponds four years after application. Adsorption rates are highest in loam, sandy clay loam, and sandy loam (Cochran et al. 1994). Granular activated carbon can be used to remove diquat to below MCL.

At its maximum application rate of 2 gallons per surface acre, the Littora® (a formulation of diquat) label for Landscape and Aquatic Herbicide specifies the following water use restrictions after treatment: 0 days for fishing and swimming, 1 day for consumption by livestock and domestic animals, 3 days for drinking, and 5 days for irrigating food crops and production ornamentals. The Restricted Entry Interval for this product is 24 hours.

VII. Proposed Treatments

Mechanical Treatments

Chena River

Diver-assisted suction dredging will be implemented to remove any isolated patches of *Elodea* occurring in the Chena River. In 2015 and 2016 Test the Waters conducted dive searches for *Elodea* in the Chena River, from the mouth of the Chena River to the mouth of Chena Slough. Throughout this section of the river, divers dove from 3 ft to the middle of the river to search the river bed for the plant, and visual searches were simultaneously conducted from shore. Only one live rooted patch of *Elodea* was found located at 64.839853, -147.849821 near the Tanana Chief Riverboat. Follow-up surveys to detect potential regrowth in this patch, or new patches of *Elodea* were conducted in 2016 and will continue on an ongoing basis. The suction dredge will be used to remove any patches of *Elodea* that are found in the river. The suction dredging activities have been permitted by the U.S. Army Corps of Engineers, and meet the non-reporting requirements for Nationwide Permit 27- Aquatic Habitat Restoration, Establishment and Enhancement.

Herbicide treatments

The herbicide treatment prescriptions for all three water bodies were formulated in consultation with aquatic herbicide specialists from SePRO Corporation.

Chena Slough

We propose to treat a 118-acre section of Chena Slough from the vicinity of Plack Road to the mouth of the slough. Pelleted and liquid formulations of fluridone will be applied in Chena Slough over a 3 – 4 year period starting in spring 2017 (Table 2). The pelleted formulation leads to a slower herbicide release, with later liquid treatment maintaining the target concentration. The use of SonarH4C (pellets, 2.7% active ingredient) is proposed for use in Chena Slough. This pellet has a lower percentage of active ingredient than SonarOne, and will be used in order to more thoroughly cover the areal surface of the slough, and make sure pesticide is present in the many backwater areas. Two treatments (spring and summer) of SonarH4C are proposed in each year of treatment (2017 – 2020). Sonar would be applied at the rate of 25 – 70 ppb in the spring and 25 – 50 ppb in the summer treatment. In addition, we propose a drip treatment of SonarGenesis (liquid) over a 12-week period in each year of treatment (Table 3). The injection station will be installed on private property upstream of the infestation, close to where Plack Rd crosses the slough. This liquid formulation will be administered via a liquid herbicide injection system (Fig. 7). This combination of Sonar pellets and injection of SonarGenesis would maintain an in-water concentration of 4 – 8 ppb of fluridone during the 12-week treatment period.

Chena Slough contains backwater areas that will be inspected during each application period for presence of *Elodea*. Many areas may require the application of SonarH4C or SonarGenesis via a backpack sprayer or small pellet spreader mounted to a barge or airboat. This would ensure coverage of all plants within the slough.

Chena Lake

We propose to conduct a whole lake treatment in Chena Lake (234 acres) (Table 3). *Elodea* cover was surveyed at seven points along the perimeter and at one point on an island in Chena Lake in 2011 (Fig. 4). Two applications of SonarOne (pellets) are proposed in the first year of treatment, in the spring and summer (Table 3). The pelleted formulations will be delivered using a granular spreader mounted on a boat (Fig. 8). One application of SonarGenesis (liquid) is proposed in the spring. During successive years of treatment a single follow up treatment of SonarOne is proposed. The projected time for treatment of the *Elodea* infestation in Chena Lake is 2- 3 years. FasTEST samples to monitor concentrations of fluridone in the water will be collected 4 times a year at 4 locations in the lake. Surveys to monitor *Elodea* density will be conducted by boat annually.

Totchaket Slough

We propose to treat the whole of Totchaket Slough, which covers an area of 232 acres (Fig.6; Table 4). Pelleted (Sonar ONE) and liquid (Sonar Genesis) formulations of fluridone will be applied to the slough over a 3-year period. In each year of treatment we propose three

applications (spring, summer, and fall) of Sonar ONE pellets. We propose to apply Sonar ONE at the rate of 30 ppb in the spring, and 20 ppb during the summer and fall treatments. We propose to apply Sonar Genesis at the rate of 5 ppb during the spring treatment. The combination of Sonar pellet applications and application of Sonar Genesis are designed to maintain an in-water concentration of Sonar of 4 – 8 ppb during the 12-week treatment cycle. Water samples for FasTEST analysis will be collected at 3 locations along the slough 5 times per year.

Pesticide Application Procedures

First, a detailed investigation of the accessibility of different areas of the infested water bodies will be conducted, and specific application methods depending on the nature of the area will be detailed. SePRO Corporation will be contracted to manage the pesticide application in all three treatment areas. All materials and pesticide application equipment will be transported to the site by truck or boat. Pesticide dispersal will be made directly into the lake or slough by DEC-certified applicators from outboard motorboats or along shorelines. Boats will be equipped with delivery systems for liquid (SonarGenesis) or pellet (SonarH4C and SonarOne) herbicide to the water.

Pellet application: In accessible areas, pelleted herbicide will be applied using a forced air blower system mounted on a motorboat. The blower system will be calibrated using clay pellets with the same size and weight as the herbicide pellets. A set weight of training pellets will be passed through the blower to measure the time required to deliver the pellets, and this will be repeated several times to obtain an average. That information will be used to determine the time required to deliver the full prescription to the treatment area. Application routes will be determined based on swath width of the blower and programmed into the onboard GPS equipment. These swaths will be followed by the operator of the application vessel. The speed will be determined by the amount of time required to deliver the prescribed weight of pellets to the treatment area. Shoreline applications of pellet herbicide will be made by hand in areas that are not readily accessible by boat. Calibrated hand spreaders will be used by applicators to distribute pelleted herbicides in areas with low water levels, or areas with thick emergent vegetation.

Liquid Application: Liquid herbicide will be applied using a pump connected to weighted hoses mounted on a motorboat in Chena Lake and Totchaket Slough. A forked intake line will draw lake or slough water and herbicide separately to be mixed and applied to the treatment area. The intake line that will draw herbicide will be metered. The intake ratios will be calibrated by running both intakes with untreated water to determine the mix ratio (gallons of water: gallons of herbicide). That ratio is combined with the pump discharge rate to determine the volume of herbicide being discharged per minute. Application routes will be determined based on swath width, programmed into the onboard GPS equipment, and followed by the operator of the application vessel.

The herbicide injection system to be installed in Chena Slough is a holding tank of herbicide with a small hose fed into the water, secured in a locked utility box (Fig. 7). The

herbicide application is metered out via a peristaltic pump. Application rates can be adjusted in real time via a secure landline. Permission for placement of an injection system has been secured on private property for Chena Slough.

The goal is to maintain a concentration of herbicide that is lethal to *Elodea* in the treatment area for 45-90 days. Periodic water sampling will be conducted to determine in-water fluridone concentration. If mean fluridone concentrations fall below 75% of the target amount for two consecutive samples, then supplemental fluridone will be added. Fluridone applications will not exceed 150 ppb in one year.

All applicators will be AK-DEC certified, and will act in accordance with all EPA label instructions. Applicators will review all safety procedures for pesticide application, including the treatment procedure for accidental exposure. As per the labels, gloves and eye protection are required to apply Sonar. Face shields or goggles will be worn for loading, mixing, clean up, repairs to equipment, or maintenance. Applicators will follow all procedures to prevent unintended exposure to the chemicals. Clean-up and equipment storage will follow all recommended procedures. There will be no eating or drinking by the applicator during application of the herbicide.

Applications of fluridone in Chena Lake and Chena Slough will take place under appropriate conditions for boating, avoiding conditions of high wind and water flow. Storage of any unused product will be in the original containers, in an appropriately secure facility (Fairbanks Fish and Wildlife Field Office, 101 12th Ave., Fairbanks, AK 99701), to ensure that no unintentional exposure to humans, animals, or the environment occurs (ADEC 2013). Warning signs for pesticide storage (in accordance with 18 AAC 90.615(e)) will be posted (ADEC 2013). Emptied containers will be triple-washed, punctured, and crushed on site immediately after use (CDTSC 2009). These containers will later be appropriately discarded in the landfill.

VIII. Monitoring and Assessment

Target and non-target attributes will be assessed pre-treatment, during treatment, and post-treatment in Chena Slough:

Non-target attributes:

1. Water quality
2. Fish and aquatic invertebrates
3. Aquatic plants other than *Elodea*

Target attributes:

4. Presence of *Elodea*
5. Concentration of fluridone

The Sample Reach

The upper reach of documented *Elodea* presence in Chena Slough is downstream of the Plack Road crossing over Chena Slough (Fig.9). Within this reach, sample collection sites will occur

below the Mission Road intersection downstream to the Plack Road intersection, with a total of four possible sample reaches. In the lower reach, including and downstream of the Plack intersection, there are a total of five intersections that can be used for sample collection sites. Water quality sample sites will be throughout the entire Chena Slough reach (above *Elodea* presence as well as below) to document the range of values prior to, during and after herbicide application. Three sample reaches for aquatic invertebrates and juvenile fish will be chosen based upon other site characteristics, based upon the presence of riffles and adult Arctic grayling. Aquatic vegetation will be sampled throughout the same sample reaches where water quality parameters were collected.

Sites

Sites for water quality and biological sampling established during a field visit on May 22, 2015.

SITE NUMBER	DESCRIPTION
CS-1	Mission Rd
CS-2	Airway Rd and Badger
CS-3	Plack Rd and Badger
CS-4	Peede Rd and Badger
CS-5	Persinger Rd

Water Quality

The following water quality parameters will be measured before, during and after the use of herbicides in the Chena Slough: pH, DO, turbidity, conductivity, and temperature. Water quality measurements will be taken at five sites from Mission Road to Persinger Road (see Sites above). In addition, dissolved oxygen will be monitored during three 24-hour periods to examine natural daily fluctuations in dissolved oxygen. All measurements will be taken in-situ with a handheld multi-meter and turbidimeter.

Fish and Aquatic Invertebrates

Five drift nets will be stationed below riffle sections so that flow coming off of the riffle will pass through the drift net. Nets will be set for 1 hour during which time the depth and flow at each drift net will be measured. Nets will be emptied into a white pan and the contents sorted through looking for juvenile fish. Any juvenile fish found will be counted, identified, measured and released. The remaining sample will be emptied into a labeled Nalgene bottle, covered with 80% denatured ethanol and stored until samples can be sorted, and aquatic invertebrates are

counted and identified. Each late May, early July, and mid-August there will be samples collected from five sample sites for a total of 15 samples. Samples will be collected pre-treatment, during treatment, and post treatment.

Native Aquatic Plants

A late season survey will be conducted from Mission Road intersection down to near the Persinger intersection for aquatic plant composition. The plan is to sample when plants are at the peak of their growing season and before senescence. A throw rake will be thrown at randomly selected locations within a sample reach. Each sample capture will be examined for plant species, number, and condition.

Presence of *Elodea*

The three targeted infestations (Chena Slough, Chena Lake and Totchaket Slough) will be annually visited to monitor for regrowth of *Elodea*. Additionally, continued surveying is essential to assess the spread of this invasive, and identify areas that may have become infested over the past 4 years. A rotating subset of the previously surveyed locations (Figs. 1 & 2) will be annually re-visited to investigate new infestations of *Elodea*. A survey protocol is in draft, based on the methods for the 2015 work throughout interior Alaska. Minor infestations will be manually controlled, or mechanically controlled in deeper waters (such as the Chena River).

Monitoring fluridone concentration

To ensure that target concentrations of fluridone are maintained, water samples will be collected routinely from each treatment area and subjected to FasTEST analysis. FasTEST is a rapid assay that measures the concentration of aquatic herbicides in water and soil samples. Chena Lake will be sampled at 4 locations, 4 times per year (locations TBD). Totchaket Slough will be sampled 5 times a year, at three locations. Chena Slough will be sampled at 10 sites, 8 times per season. All water samples will be collected using FasTEST protocols established by SePRO, and sent by overnight delivery to SePRO Corporation's analytical laboratory in Carmel, IN for immunoassay following the techniques described by Netherland et al. (2002). Approximately ~10% of water samples will be duplicated and analyzed by an independent lab. All test results will be made available on FSWCD's website (<http://www.fairbankssoilwater.org/>). Chena Slough residents will be notified of treatment plans, irrigation restrictions and the availability of test results via mail before any treatment begins.

To examine whether fluridone is migrating into groundwater, sediment cores and well water will also be tested post-treatment, pending landowner and subsurface water rights. Depending on the depth of a well, it is expected that fluridone concentrations in drinking water wells will be negligible due to fluridone's chemical properties to be transported through soils. The soil organic carbon partitioning coefficient (Koc values) for fluridone range from 70 to 2700 for different types of soils; ~2700 in 60% clay with only 1.8% organic matter, and ~270 in fine sandy loam with 8.5% clay and 1.7% organic matter. The higher the Koc value, the less mobile

organic chemicals are, while the lower the Koc value, the more mobile the organic chemicals are. Chena Slough is dominated by fine-grained, organic-rich sediments (Kennedy and Hall 2009), which are more likely to reflect higher Koc values for fluridone in the treatment area, reassuring that fluridone will not travel more than a few inches into the soil. Both SePRO Corporation and a third party will be utilized to determine concentrations.

IX. Preventing the spread of *Elodea*

Outreach and Education

The treatments for eradication of *Elodea* proposed in this IPM plan will affect multiple user groups in the Fairbanks and North Pole areas. Chena Slough is lined by private residences and used year-round for recreational activities such as boating, fishing, and snow machining. Chena Lakes is a popular recreation area for swimming, fishing (summer and winter), and non-motorized boating. Also the Chena River is heavily populated and provides many of the same outdoor recreational activities. Engaging the public on the issue of *Elodea*, and educating them about boat and equipment cleaning are crucial to minimizing the spread of *Elodea* fragments from the existing infestations to new areas. Additionally, describing the life history of the plant, its effects on aquatic habitats, and the pros and cons of control options will provide the public with a better understanding for future actions.

Priorities for outreach:

- 1) Garner awareness and support for the proposed treatment plan.
 - Engage local print and radio media outlets about the dangers of *Elodea* and the planned treatment in affected water bodies.
 - Public meetings with residents in the North Pole area (required by permitting process).
 - Public meetings with residents in Nenana (required by permitting process).
 - Host *Elodea* Day at Chena Lakes Recreation Area, an informational public event co-sponsored by the Fairbanks North Star Borough.
 - Maintain an up-to-date website containing information on *Elodea* and the treatment plan.
 - Keep civic leaders informed of the *Elodea* treatment plan.
 - Work with Chena Slough residents to find other irrigation sources during the treatment period

- 2) Prevent spread and re-introduction of *Elodea* in interior Alaska.
 - Deploy signage providing information about *Elodea* and instructions on boat cleaning, as well as informational brochures, at key recreational areas and boat launches along the Chena River, and float plane ponds in the city of Fairbanks, near Nenana, and at Chena Lakes Recreation Area.
 - Outreach in villages along the Yukon and Tanana to raise *Elodea* awareness and promote clean boating practices.

- Ongoing cooperation with the Salcha-Delta SWCD to continue surveying for *Elodea*.
- Present at local and statewide conferences and workshops about the presence of *Elodea* and efforts towards eradication in interior.
- Continue outreach at public events in the Fairbanks area to raise awareness about *Elodea*.
- Ongoing surveying efforts throughout interior Alaska (see ‘Monitoring.’)

DRAFT

X. Budget

Eradication of *Elodea* in the Chena River watershed (Chena Slough, Chena Lake, Chena River, and Totchaket Slough) will be a 3-4 year endeavor. Below is an estimate of the annual costs for purchasing the herbicide. The cost of application goes down in successive years. Moreover, there is a possibility actual costs will be considerably lower than these estimates, especially if *Elodea* is eradicated from Chena Slough in three years, and the fourth year of herbicide application is deemed unnecessary. Some of the application equipment will be available on loan from Kenai National Wildlife Refuge. The cost of the liquid herbicide injection system is approximately \$15,000.

BUDGET			
Year	Waterbody	Cost of herbicide	Total
1	Chena Slough	\$148,000	\$337,020
	Chena Lake	\$98,700	
	Totchaket Slough	\$90,320	
2	Chena Slough	\$137,000	\$274,320
	Chena Lake	\$47,000	
	Totchaket Slough	\$90,320	
3	Chena Slough	\$137,000	\$274,320
	Chena Lake	\$47,000	
	Totchaket Slough	\$90,320	
4	Chena Slough	\$108,000	\$108,000
	Chena Lake	\$0	
	Totchaket Slough	\$0	
TOTAL			\$993,600

The cost of herbicides needed for eradicating *Elodea* in each of the three infested water bodies is:

Chena Slough total cost of herbicides (4 years): **\$530,000**

Chena Lake total cost of herbicides (3 years): **\$192,700**

Totchaket Slough total cost of herbicides (3 years): **\$270,960**

XI. Administrative Record

July 2009 – Specimen collected from the Chena Slough, vouchered at UA Herbarium.

September 2010 – Floating fragments of *Elodea* were found in the Chena River. Dense infestation found upstream in Chena Slough. Plants recognized as invasive.

December 2010 – Public meeting, Elodea Steering Committee formed. FSWCD takes lead.

April 2011 –“Control Options for *Elodea* spp. in the Chena Slough near Fairbanks, Alaska” white paper written.

Summer 2011 – Extensive surveying in Tanana Valley watershed. *Elodea* discovered in Chena Lake.

Summer 2012 – Survey of Chena Lake perimeter. Tanana Valley Watershed Association surveyed the Chena River.

Summers 2013 & 2014 – Trials for mechanical and manual removal of *Elodea* in the Chena Slough conducted by FSWCD and Test the Waters Dive Shop.

March 2014 – DNR quarantine of *Elodea* for the state of Alaska.

December 2014 – Public meeting in North Pole.

January 26th 2015 – Elodea Steering Committee re-convened, monthly meetings hereafter.

April 2015 – Informational meeting. 1st draft Integrated Pest Management.

June 18th 2015 – Public meeting in North Pole.

Summer 2015 – Extensive surveys for *Elodea* in interior Alaska. Discovery of *Elodea* in the Totchaket Slough north of Nenana. Ongoing mechanical removal of *Elodea* in the Chena Slough.

September 2015 – First draft DEC Pesticide Use Permit (PUP) for fluridone.

January 26th 2016 – DEC PUP submitted by DNR

February 8th 2016 – Start of DEC public commenting period on the Pesticide Use Permit

February 12th 2016 – Funds for herbicides requested from Alaska State Legislature

February 29th 2016 – First draft of NEPA Environmental Assessment

March 7th & 8th 2016 – Public meetings held in Fairbanks, North Pole, and Nenana.

March 8th 2016 – End of public commenting period

April 2016 – Pesticide Use Permit revised to address concerns raised at the public meetings. Sonar Genesis Special Local Need 24(c) label prepared by SePRO, submitted to EPA and approved. The revised permit reflected: 1) more detailed information on wells within the treatment area, 2) increased water and sediment sampling, and 3) inclusion of the 24(c) for Sonar Genesis.

April 29th 2016 – Revised PUP submitted to DEC for review.

May 1st and May 2nd – Public Notification of the DEC public commenting period on the Pesticide Use Permit posted

June 2nd – Public commenting period ended.

November 9th 2016 – DEC completed its evaluation of the pesticide use permit application, and issued a permit to Alaska Department of Natural Resources, Division of Agriculture (Permit No. 16-AQU-07) for the application of Sonar Genesis, Sonar One, and Sonar H4C all with active ingredient fluridone to waters of the state to control invasive Elodea in Chena Lake, Chena Slough, and Totchaket Slough in the Fairbanks area.

January 3rd 2017 – The Draft Environmental Assessment for the Interior Alaska Elodea Eradication Project was submitted by ADNR, Division of Agriculture to the U.S. Fish and Wildlife Service for review. The public commenting period on the draft EA will end on February 3rd 2017.

XII. Figures and Tables

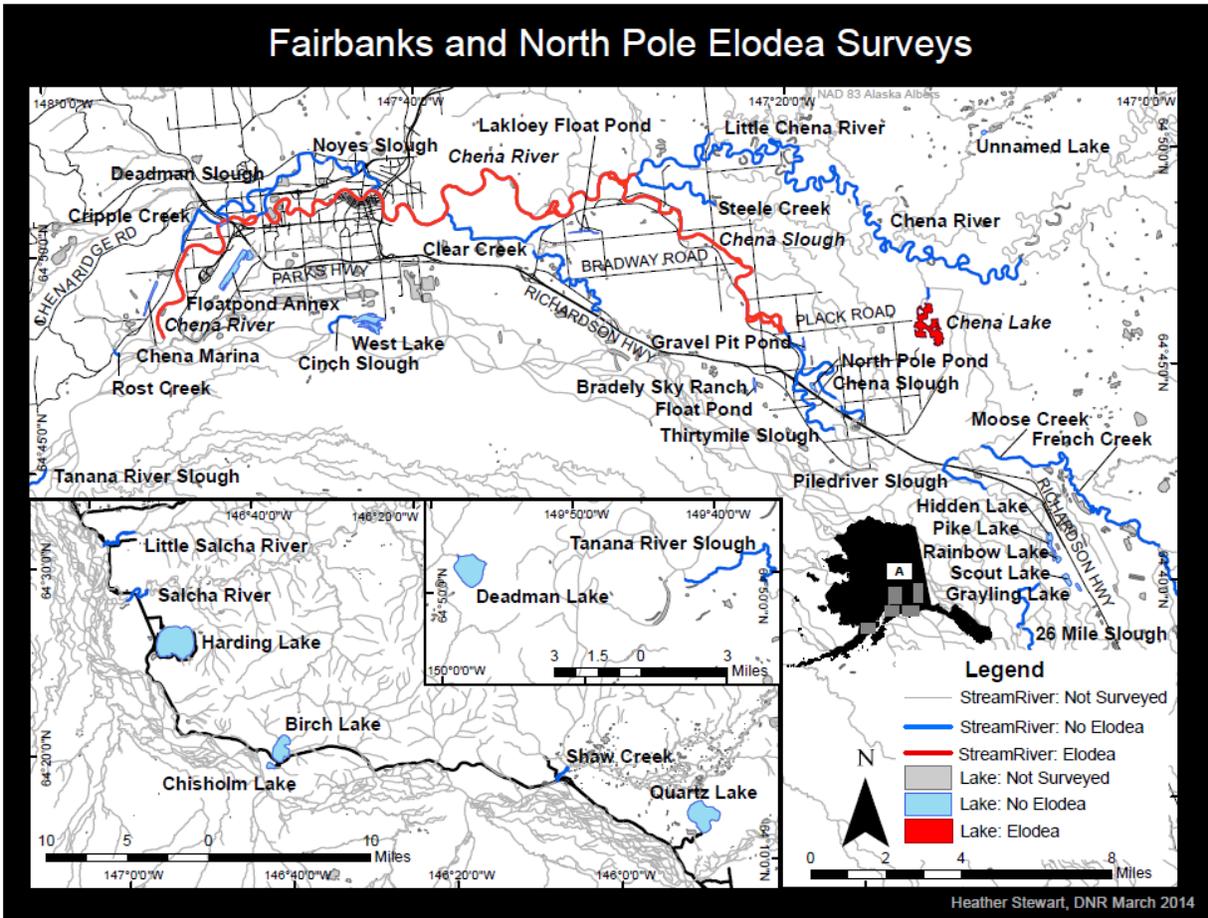


Fig.1 Map showing water bodies in the Fairbanks and North Pole areas that were surveyed for *Elodea* in 2011.

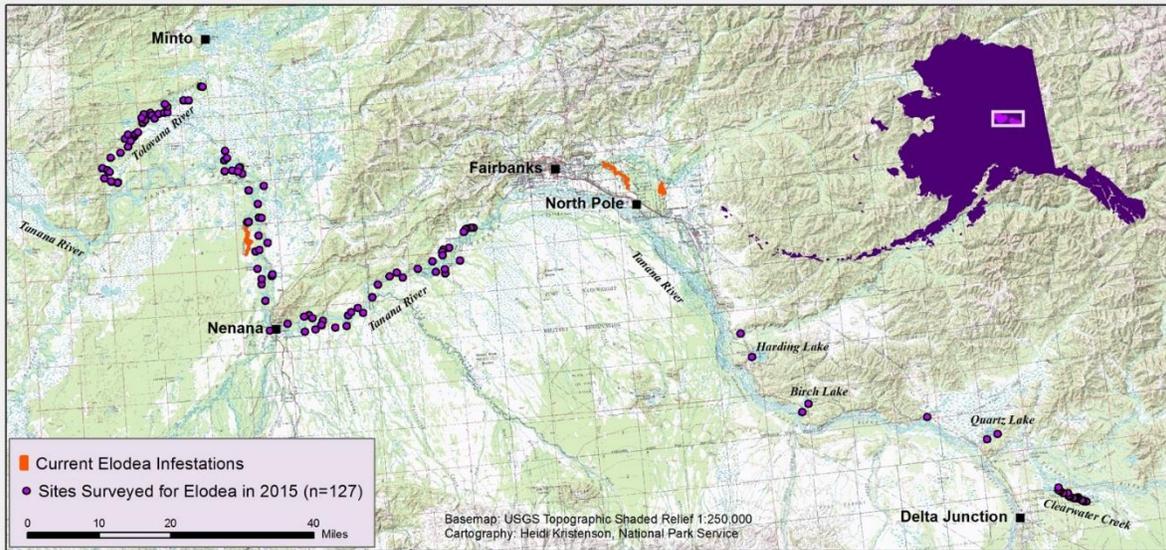


Fig.2 Locations of known *Elodea* infestations in interior Alaska, and 2015 survey locations.

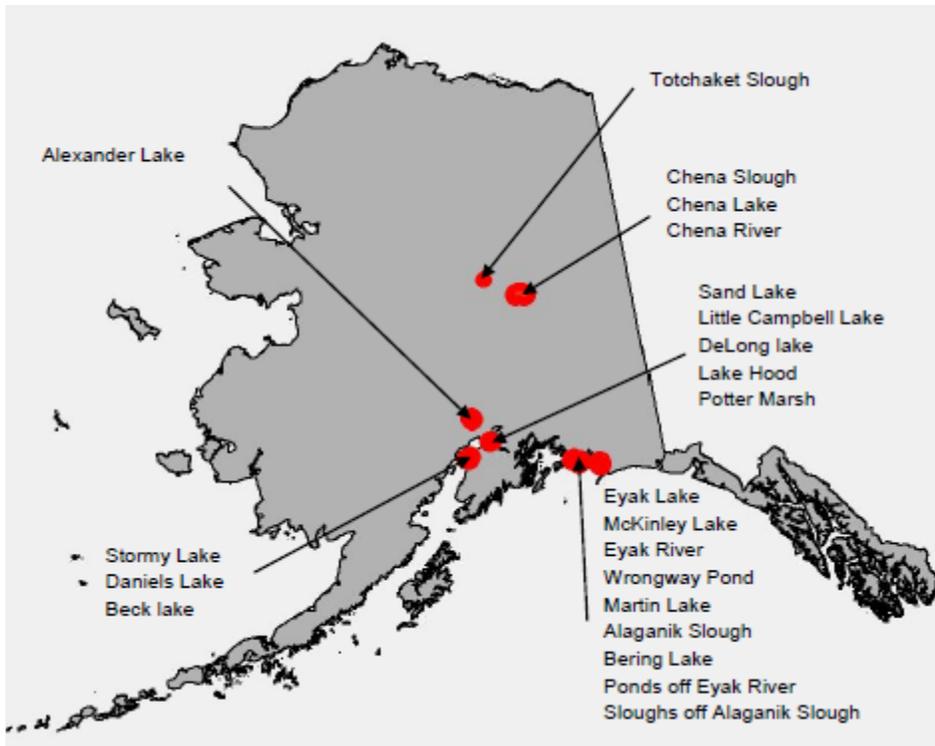


Fig.3 Map indicating the locations of known Elodea infestations within the state of Alaska.

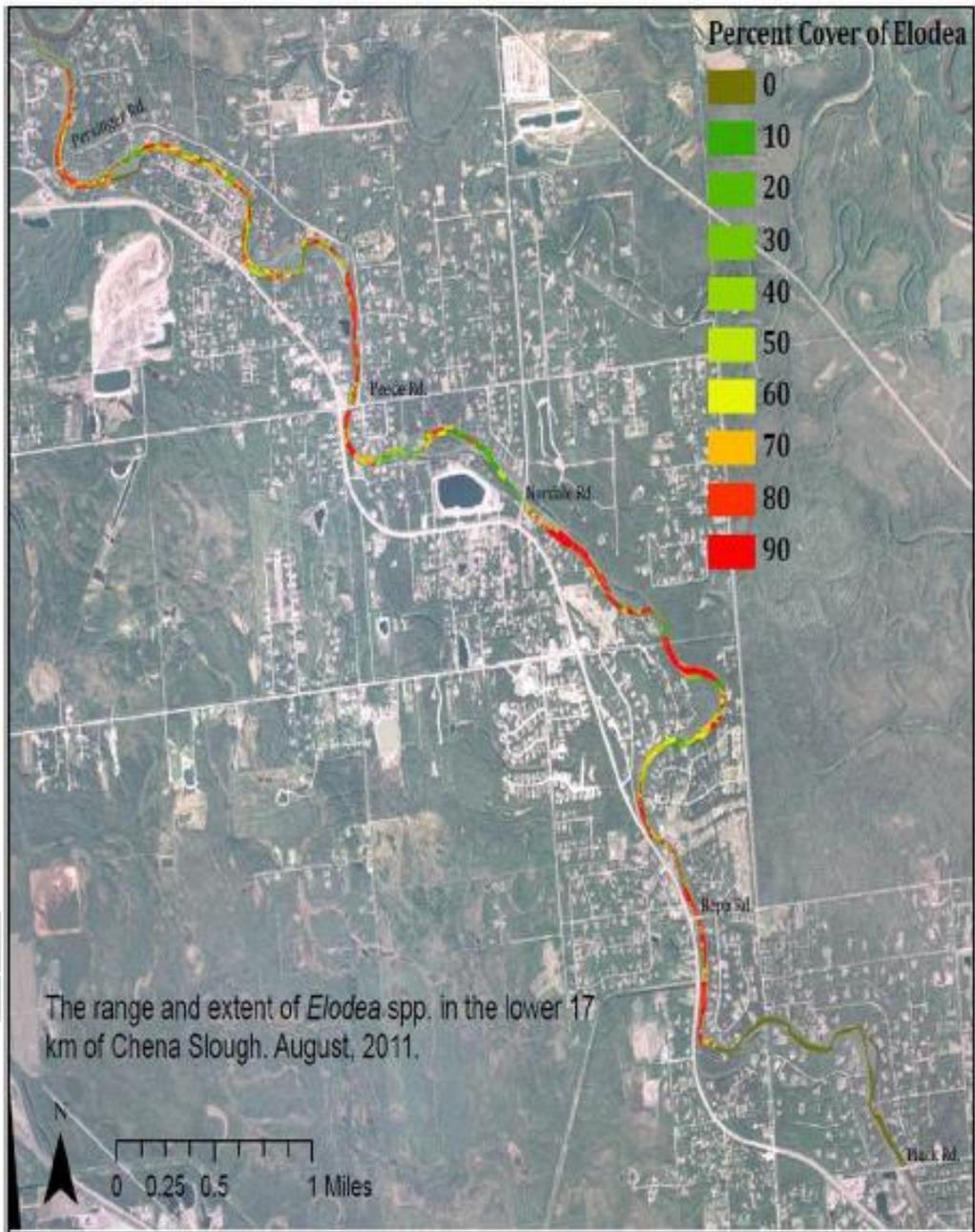


Fig. 4 Variations in density of *Elodea* within the Chena Slough infestation, measured in 2011.

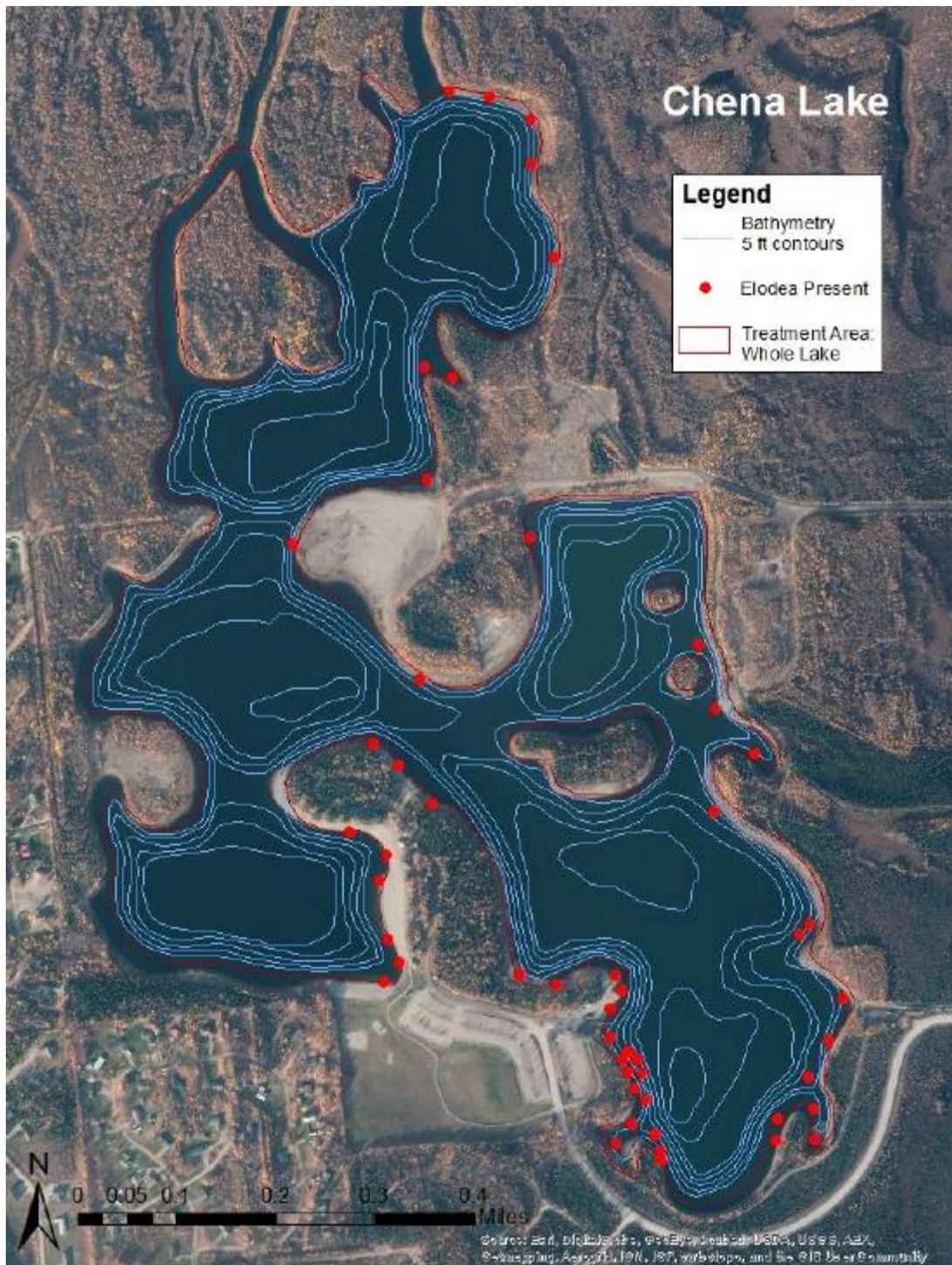


Fig.5 *Elodea* locations in Chena Lake, measured in 2012.

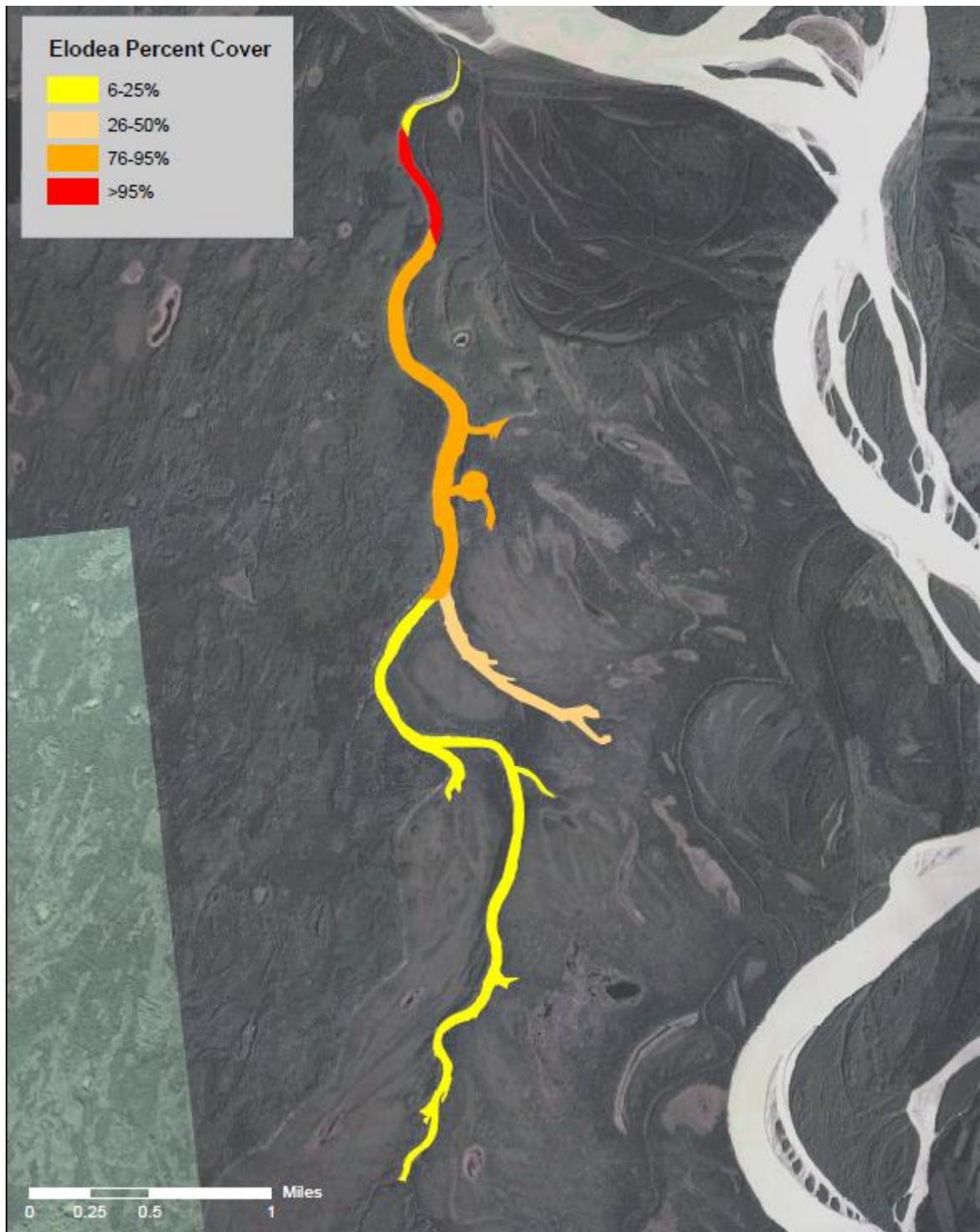


Fig. 6 Variation in *Elodea* density throughout the infestation in Totchaket Slough.



Fig. 7 Herbicide drip system apparatus for delivery of liquid herbicide (Sonar Genesis).



Fig. 8 Vortex granular spreader system mounted to a boat for application of pelleted herbicide (Sonar ONE and Sonar H4C).

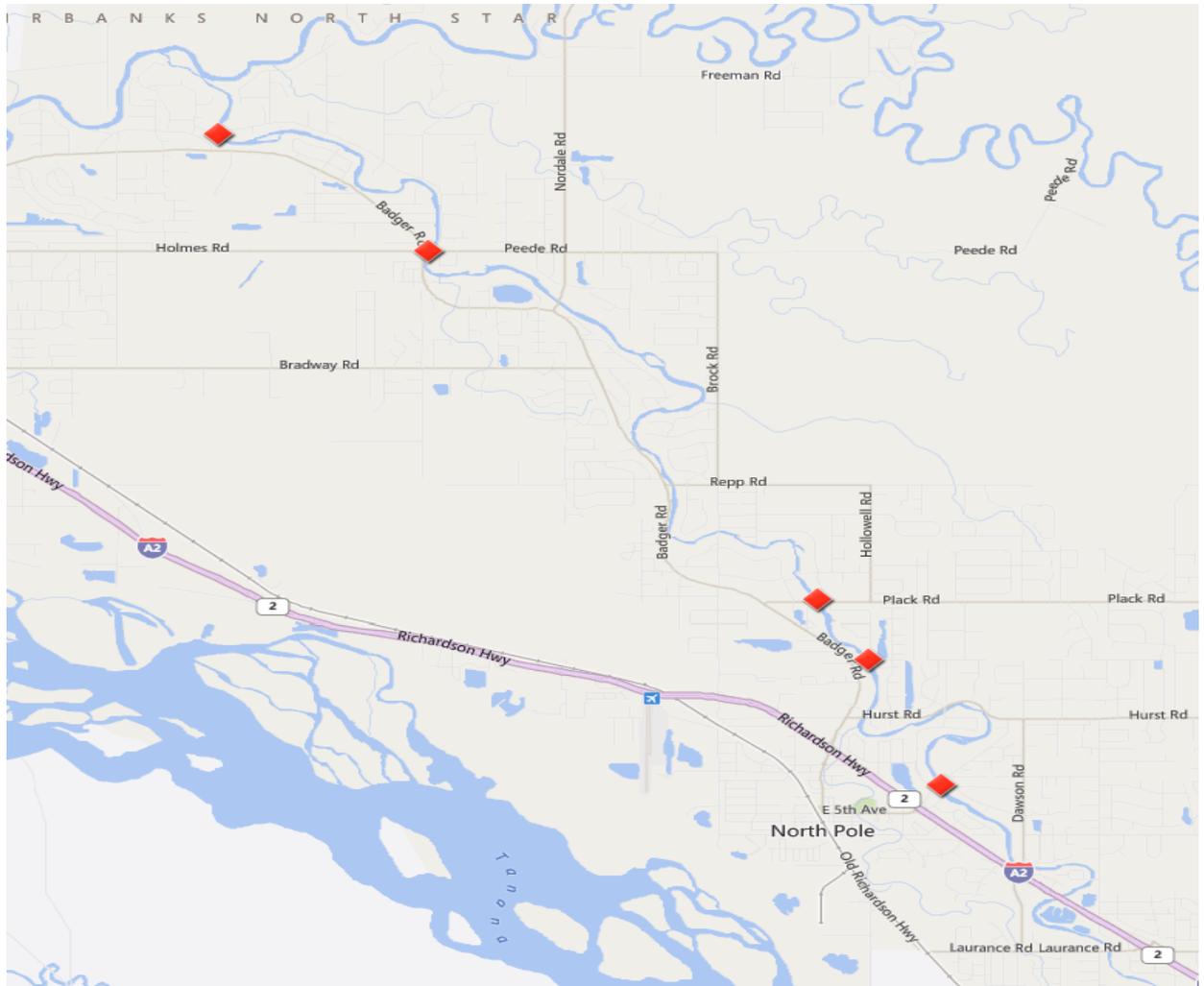


Fig.9 Location of monitoring sites along Chena Slough

Table 1. Comparison of aquatic herbicides. Herbicides in **bold** considered further.

Aquatic Herbicide	LD-50 in rats (mg/kg body weight)	Mode of action	Further considerations
2,4-D	375-666	Systemic	Some formulations are highly toxic to fish. Potentially carcinogenic and an endocrine disruptor.
Acrolein	50	Contact	Non-specific, highly toxic biocide. Not appropriate for use in natural waters.
Copper sulfate pentahydrate	300	Systemic	Toxic to fish.
Diquat	120	Contact	Swiftly diluted in moving waters.
Endothall	51	Contact	May kill native plants. Cannot be applied within 600 feet of a drinking water well. Some formulations highly toxic to fish.
Flumioxazin	>5,000	Systemic	Not effective on Elodea (Glomski & Netherland 2013).
Fluridone	>10,000	Systemic	May injure some susceptible aquatic plants. Irrigation restrictions apply.
Glyphosate	5,600	Systemic	Effective only on plants that grow above water, non-specific to Elodea.
Imazamox	>5000	Systemic	Sensitivity of Elodea and native plants unknown.
Imazapyr	>5000	Systemic	Not effective on submerged plants.
Penoxsulam	> 5,000	Systemic	Likely to move into groundwater, some evidence of carcinogenic effects.
Triclopyr	630-729	Systemic	Ineffective in moving waters.

Table 2. Detailed application prescription for Chena Slough treatment

Year	Product	Application 1		Application 2	
		Rate (ppb)	gal or lbs	Rate (ppb)	gal or lbs
1	Sonar Genesis	8.0	244.0		
	Sonar H4C	70.0	2494.6	50.0	1781.8
2	Sonar Genesis	8.0	232.0		
	Sonar H4C	50.0	1781.8	40.0	1687.3
3	Sonar Genesis	8.0	232.0		
	Sonar H4C	50.0	1781.8	40.0	1687.3
4	Sonar Genesis	4.0	164.7		
	Sonar H4C	50.0	1781.8	25.0	1054.6

DRAFT

Table 3. Detailed application prescription for Chena Lake treatment

Year	Product	Application 1		Application 2	
		Rate (ppb)	gal or lbs	Rate (ppb)	gal or lbs
1	Sonar Genesis	7.0	141.7		
	SonarONE	6.0	1214.6	3.0	607.3
2	SonarONE	7.0	1417.0		
3	SonarONE	7.0	1417.0		

DRAFT

Table 4. Detailed application prescription for Totchaket Slough treatment

Year	Product	Application 1		Application 2		Application 3	
		Rate (ppb)	gal or lbs	Rate (ppb)	gal or lbs	Rate (ppb)	Gal or lbs
1	Sonar Genesis	5.3	20.0				
	SonarONE	30.0	1127.5	20.0	751.7	20.0	751.7
2	Sonar Genesis	5.3	20.0				
	SonarONE	30.0	1127.5	20.0	751.7	20.0	751.7
3	Sonar Genesis	5.3	20.0				
	SonarONE	30.0	1127.5	20.0	751.7	20.0	751.7

DRAFT

XIII. References

- Arctic Climate Impact Assessment (ACIA). 2005. *Impacts of a warming climate: arctic climate impact assessment*. Cambridge University Press, Cambridge, UK.
- Alaska Dept of Environmental Conservation (ADEC). 2013. Chapter 90: Pesticide Control. Available at: <https://dec.alaska.gov/commish/regulations/pdfs/18%20AAC%2090.pdf> Accessed 23 Nov 2015.
- Alaska Dept of Fish & Game (ADFG). 2011. Chena Lake Recreation Area. <http://www.adfg.alaska.gov/index.cfm?adfg=viewinglocations.chenalake>, Accessed 29 Nov 2011.
- Alaska Dept of Fish & Game (ADFG). 2016. Alaska Sport Fishing Survey database. 1996–2016. Anchorage, AK: Alaska Department of Fish and Game, Division of Sport Fish. Available from: <http://www.adfg.alaska.gov/sf/sportfishingsurvey/> Accessed March 21, 2016.
- Barrat-Segretain, M., A. Elger, P. Sagnes and S. Puijalon. 2002. Comparison of three life-history traits of invasive *Elodea canadensis* Michx. and *Elodea nuttallii* (Planch.) H. St. John. *Aquatic Botany* 74: 299-313.
- Barrat-Segretain, M. and A. Elger. 2004. Experiments on growth interactions between two invasive macrophyte species. *Journal of Vegetation Science* 15.1: 109-114.
- Bartels, P. and C. Watson. 1978. Inhibition of carotenoid synthesis by fluridone and norflurazon. *Weed Science* 26(2): 198-203.
- Beattie, L., C. Rich, C. Everett, J. Rogers, L. Jacobs, B. Spellman, B. Million, and T. Wurtz. 2011. Control Options for *Elodea* spp. in the Chena Slough near Fairbanks, Alaska: A compilation of potential treatments. Fairbanks Soil and Water Conservation District White Paper. Available at: http://www.fairbanksweeds.org/user-files/ElodeaControlOptions_20110503.pdf Accessed 23 Nov 2015.
- Best, E.P.H., H. Woltman and F.H. Jacobs. 1996. Sediment-related growth limitation of *Elodea nuttallii* as indicated by a fertilization experiment. *Freshwater Biology* 36(1): 33-44.
- Bimber, K.L., R.W. Boenig and M.L. Sharma. 1976. Respiratory stress in yellow perch induced by subtoxic concentrations of diquat. *Ohio Journal of Science* 76(2): 87-90.
- Bowmer, K.H., D.S. Mitchell, and L. David. 1984. Biology of *Elodea canadensis* Mich. and its management in Australian irrigation systems. *Aquatic botany* 18(3): 231-238.
- Bowmer, K.H., S.W.L. Jacobs and G.R. Sainty. 1995. Identification, biology and management of *Elodea canadensis*, Hydrocharitaceae. *Journal of Aquatic Plant Management* 33: 13-19.
- Brase, A.L.J. 2009. Sport fishery management plan for Chinook salmon in the Chena and Salcha Rivers. *Fishery Management Report* No. 09-11, Alaska Department of Fish and Game.
- Buscemi, P.A., 1958. Littoral oxygen depletion produced by a cover of *Elodea canadensis*. *Oikos* 9: 239-245.
- California Department of Toxic Substances Control (CDTSC). 2009. *Managing Empty Containers*. Available at: http://ehs.ucr.edu/waste/DTSC_Empty%20Containers%20Fact%20Sheet.pdf Accessed 13 Dec 2015.
- Catlin, P.M. and W. Wojtas. 1985. The waterweeds (*Elodea* and *Egeria*, Hydrocharitaceae) in Canada. *Canadian Journal of Botany* 64:1525-1541.

- Centre for Aquatic Plant Management (CAPM). 2004. Information Sheet 25: *Elodea nuttallii*, Nuttall's Pondweed. Available at: http://nora.nerc.ac.uk/10425/2/N010425_leaflet.pdf
Accessed 10 Mar 2016
- Chena Slough Technical Advisory/Restoration Committee. 2005. Executive Summary: Chena Slough Adaptive Restoration Plan.
- Cochran, R. C., M.H. Silva, C. Gerald and A.F. Tareq. 1994. Diquat dibromide risk characterization document. *Medical Toxicology and Worker Health and Safety Branches, Department of Pesticide Regulation, California Environmental Protection Agency*.
- Colle, D. E., J.V. Shireman, W.T. Haller, J.C. Joyce, and D.E. Canfield, Jr. 1987. Influence of hydrilla on harvestable sport-fish populations, angler use, and angler expenditures at Orange Lake, Florida. *North American Journal of Fisheries Management* 7(3): 410-417.
- Cook, C.D.K. and K. Urmi-König. 1985. A revision of the genus *Elodea* (Hydrocharitaceae). *Aquatic Botany* 21:111-156.
- Dion, C.A. 2002. Growth, foraging behavior and distribution of age-0 Arctic grayling in an Alaskan stream (Master's thesis). University of Alaska Fairbanks, Fairbanks, AK.
- DiTomaso, J.M., G.B. Kyser et al. 2013. *Weed control in Natural Areas in the Western United States*. Weed Research and Information Center, University of California. 554 pp.
- Emmett, K., 2002. *Final Risk Assessment for Diquat Bromide: Appendix A*. Washington State Department of Ecology.
- Durkin, P.R. 2008. Fluridone: Human Health and Ecological Risk Assessment Final Report. Syracuse Environmental Research Associates, Inc. Internal Task No.: 52-10.
- Fairbanks North Star Borough (FNSB). Chena Lake Recreation Area. Available at: <http://co.fairbanks.ak.us/>, Accessed 29 Nov 2011.
- Gilder, C. 2011. Section 319: Nonpoint source program success story. Alaska Department of Conservation. EPA 841-F-11-001C.
- Glomski, L.M. and M.D. Netherland. 2013. Use of a small-scale primary screening method to predict effects of flumioxazin and carfentrazone-ethyl on native and invasive, submersed plants. *Journal of Aquatic Plant Management* 51: 45-48.
- Gollasch, S. 2006. Overview on introduced aquatic species in European navigational and adjacent waters. *Helgoland Marine Research* 60(2): 84-89.
- Gosselin, R.E., R.P Smith and H.C. Hodge. 1984. *Clinical toxicology of commercial products*. Fifth edition. Baltimore, MD: Williams and Wilkins.
- Heikkinen, R.K., N. Leikola, S. Fronzel, R. Lampinen and H. Toivonen. 2009. Predicting distribution patterns and recent northward range shift of an invasive aquatic plant: *Elodea canadensis* in Europe. *BioRisk* 2: 1-32.
- Hamelink, J.L., D.R. Buckler, F.L. Mayer, D.U. Palawski, and H.O. Sanders. 1986. Toxicity of fluridone to aquatic invertebrates and fish. *Environmental Toxicology and Chemistry* 5(1): 87-94.
- Hayes, W.J. and E.R. Laws (ed.). 1990. *Handbook of pesticide toxicology*, Vol. 3, Classes of pesticides. Academic Press, Inc., NY.
- Horsch, E.J. and D.J. Lewis. 2008. *The effects of aquatic invasive species on property values: Evidence from a quasi-random experiment*. University of Wisconsin-Madison Department of Agricultural & Applied Economics, Staff Paper No. 530.
- Hydraulic Mapping and Modeling, 2013. *Chena Slough hydrologic and hydraulic analysis for existing conditions and channel modifications: Final report*. Prepared for Fairbanks Soil and Water Conservation District.

- Ihlenfeldt, N.J. 2006. *Restoration of sloughs in the Fairbanks North Star Borough (Tanana River Watershed)*. The Alaska Department of Natural Resources, Office of Habitat Management and Permitting. Technical Report No. 06-02.
- Johnson, L.S., S.D. Rindge and D.A. Gaskin. 1981. Chena River Lakes project revegetation study- Three Year Summary. *Cold Regions Research and Engineering Laboratory Report* 81-18.
- Josefsson, M. and B. Andersson. 2001. The environmental consequences of alien species in the Swedish lakes Malaren, Hjalmaran, Vanern, and Vattern. *Ambio* 30(8): 514-521.
- Kamarianos, A., J. Altiparmakis, X. Karamanlis, D. Kufidis, T. Kousouris, G. Fotis, and S. Kilikidis. 1989. Experimental evaluation of fluridone effectiveness on fish productive aquatic ecosystems. *Journal of Aquatic Plant Management* 27: 24-26.
- Kennedy, B.W., and C.C. Hall. 2009. Occurrence of selected nutrients, trace elements, and organic compounds in streambed sediment in the lower Chena River watershed near Fairbanks, Alaska, 2002–03. *U.S. Geological Survey Scientific Investigations Report* 2009-5067, 28 p.
- Kenaga, D. 1992. *The impact of the herbicide Sonar on the aquatic plant community in 21 Michigan lakes: 1992*. Inland Lakes Management Unit, Land and Water Management Division, Michigan Department of Natural Resources.
- Kennedy, B. W., Hall, C. C. 2009. Occurrence of Selected Nutrients, Trace Elements, and Organic Compounds in Streambed Sediment in the Lower Chena River Watershed near Fairbanks, Alaska, 2002-03. USGS Scientific Investigation Report 2009-5067.
- Lane, R. 2014. *Chena Slough Elodea control trial project: 2013 overview*. Fairbanks Soil and Water Conservation District, white paper.
- Langeland, K.A., and J.P. Warner. 1986. Persistence of diquat, endothall, and fluridone in ponds. *Journal of Aquatic Plant Management* 24: 43-46.
- Madsen, J. D., K. D. Getsinger, R. M. Stewart and C. S. Owens. 2002. Whole lake fluridone treatments for selective control of Eurasian watermilfoil: II. Impacts on submersed plant communities. *Lake and Reservoir Management* 18(3): 191-200.
- Marquis, L., R. Comes and C. Yang. 1981. Absorption and translocation of fluridone and glyphosate in submersed vascular plants. *Weed Science* 29(2): 229-236.
- McCorkelle, G., G.R. Sainty and K.H. Bowmer. 1992. *Evaluation of Sonar (Fluridone) for aquatic plant management in Australia*. Final report for Dow Elanco Australia Ltd, Consultancy Report No 92/2. CSIRO Division of Water Resources, Griffith NSW. 58pp.
- McCowen, M., C. Young, S. West, S. Parka and W. Arnold. 1979. Fluridone, a new herbicide for aquatic plant management. *Journal of Aquatic Plant Management* 17: 27-30.
- Morton, John M., et al. 2014. *Integrated Pest Management Plan for Eradication Elodea from the Kenai Peninsula*. Elodea Subcommittee of the Kenai Peninsula Cooperative Weed Management Area.
- Mjelde, M., P. Lombardo, D. Berge and S.W. Johansen. 2012. Mass invasion of non-native *Elodea canadensis* Michx. in a large, clear-water, species-rich Norwegian lake—impact on macrophyte biodiversity. *Annales de Limnologie-International Journal of Limnology* 48(2): 225-240.
- Muir, D., N. Grift, A. Blouw, and W. Lockhart. 1980. Persistence of fluridone in small ponds. *Journal of Environmental Quality* 9(1): 151-156.
- Muir, D.C.G. and N.P. Grift. 1982. Fate of fluridone in sediment and water in laboratory and field experiments. *Journal of Agricultural and Food Chemistry* 30 (2): 238-244.

- Muir, D., N. Grift, B. Townsend, D. Metner, and W. Lockhart. 1982. Comparison of the uptake and bioconcentration of fluridone and terbutryn by rainbow trout and *Chironomus tentans* in sediment and water systems. *Archives of Environmental Contamination and Toxicology* 11: 595-602.
- Neill, C. R., J.S. Buska, E.F. Chacho, C.M. Collins and L.W. Gatto. 1984. Chena River Lakes Project, Fairbanks, Alaska. Overview of Tanana River Monitoring Research Studies Near Fairbanks, Alaska. *Cold Regions Research and Engineering Lab SR-84-37*. Hanover NH.
- Netherland, M. D., D. R., A. G. Staddon and K. D. Getsinger. 2002. Comparison of immunoassay and HPLC for analyzing fluridone concentrations: New applications for immunoassay techniques. *Lake and Reservoir Management* 18(1):75-80.
- Nichols, S.A., and B.H. Shaw. 1986. Ecological life histories of the three aquatic nuisance plants, *Myriophyllum spicatum*, *Potamogeton crispus* and *Elodea canadensis*. *Hydrobiologia* 131.1: 3-21.
- Nicholson, S. A. and R. J. Clerman. 1974. Toxicity of diquat to the crustacean amphipod *Hyaella* from Chautauqua Lake. *Environmental Letters* 7(4):215-227.
- New York State Federation of Lake Associations (NYSFOLA). 2009. *Diet for a Small Lake*. 2d ed. Lafayette, NY.
- Oreska, M. P. and D.C. Aldridge. 2011. Estimating the financial costs of freshwater invasive species in Great Britain: a standardized approach to invasive species costing. *Biological Invasions* 13(2): 305-319.
- Osborne, J., S. West, R. Cooper, and D. Schmitz. 1989. Fluridone and N-methylformamide residue determinations in ponds. *Journal of Aquatic Plant Management* 27: 74-78.
- Pokorný, J., J. Květ, J. P. Ondok, Z. Toul, and I. Ostrý. 1984. Production-ecological analysis of a plant community dominated by *Elodea canadensis* Michx. *Aquatic botany* 19(3): 263-292.
- Portland State University Center for Lakes and Reservoirs. 2009. Introduction to common native and potential invasive freshwater plants in Alaska. *prepared for* Alaska Department of Fish and Game, U.S. Fish and Wildlife Service Coastal Program, and U.S. Fish and Wildlife Service Aquatic Invasive Species Program.
- Rorslett, B., D. Berge, and S. W. Johansen. 1986. Lake enrichment by submersed macrophytes: A Norwegian whole-lake experience with *Elodea canadensis*. *Aquatic Botany* 26: 325-340.
- Sand-Jensen, K. 2000. An introduced vascular plant - the Canadian waterweed. In: Weidema, I. (ed.). *Introduced species in the Nordic countries*. Norden (The Nordic Council), Copenhagen, Denmark.
- Sax, N. I. 1984. *Dangerous properties of industrial materials*. Sixth edition. NY.: VanNostrand Reinhold Company.
- Schneider, J.C. 2000. Evaluation of the effects of the herbicide Sonar on sport fish populations in Michigan lakes. Michigan Department of Natural Resources, *Fisheries Technical Report No. 2000-2*. 35 pp.
- Skogerboe, J.G., K.D. Getsinger, and L.M. Glomski. 2006. *Journal of Aquatic Plant Management* 44: 122-125.
- Sculthorpe, C.D. 1967. *The biology of aquatic vascular plants*. Edward Arnold Ltd, London.
- Spicer, K. W., and P. M. Catling. 1988. The biology of Canadian weeds: 88. *Elodea canadensis* Michx. *Canadian Journal of Plant Science* 68(4): 1035-1051.

- Stuckey, R.L., J.R. Wehrmeister and R.J. Bartolotta. 1978. Submersed aquatic vascular plants in ice-covered ponds of central Ohio. *Rhodora*: 575-580.
- Talbot, B., A. Plager, B. Ludwig, and D. Hunt. 2006. *Chena River State Recreation Area Management Plan*. Alaska Division of Parks and Outdoor Recreation.
- Tetra Tech, Inc. 2011. *Watershed Characterization for the Chena River Watershed, Alaska*. Prepared for US Environmental Protection Agency and Alaska Department of Environmental Conservation.
- United States Army Corps of Engineers (USACE). 1997. *Chena River Watershed Study, Reconnaissance Report*. Anchorage, AK.
- U. S. Environmental Protection Agency (USEPA). 1986. *Pesticide Fact Sheet: Fluridone*. No. 81, 5 pp.
- U. S. Environmental Protection Agency (USEPA). 2002. *Tolerance Reassessment Progress and Risk Management Decision (TRED) for Diquat Dibromide*. Available from http://archive.epa.gov/pesticides/reregistration/web/pdf/diquat_tred.pdf
- U.S. Environmental Protection Agency (USEPA). 2004. Human health risk assessment for fluridone TRED (Tolerance Reassessment Eligibility Decision). In Durkin 2008
- Washington State Department of Ecology (WADOE). 2002. *Supplemental environment impact statement assessments of aquatic herbicides: DRAFT volume 6 – copper*. Washington State Department of Ecology, Olympia, Washington.
<http://www.ecy.wa.gov/programs/wq/pesticides/enviroReview/riskAssess/copperrisk.pdf>
- Westerdahl, H.E. and K.D. Getsinger. 1988. Aquatic plant identification and herbicide use guide: aquatic plants and susceptibility to herbicides. In *Aquatic plant identification and herbicide use guide: aquatic plants and susceptibility to herbicides*. Department of the Army.
- Williams, J.A. 1950. Navigation difficulties caused by U.S. smelting, refining, and mining company (Chena Slough). *Alaska Territorial Department of Mines Miscellaneous Report* 58-7, 9 p. doi:10.14509/795
- Wilson, D. C. and C. E. Bond. 1969. The effects of the herbicides diquat and dichlobenil (Casoron) on pond invertebrates. Part I. Acute toxicity. *Transactions of the American Fisheries Society* 98(3): 438-443.
- Wurtz, T.L., N. Lisuzzo, A. Batten and A. Larsen. 2013. Request for analysis of native status of elodea in Alaska. Internal letter dated April 8th. USDA Forest Service, Alaska Region State and Private Forestry, Forest Health Protection, Fairbanks, AK.
- Zhang, C. and Boyle, K. J. 2010. The effect of an aquatic invasive species (Eurasian watermilfoil) on lakefront property values. *Ecological Economics* 70(2): 394-404.